Organizing Digital Innovation in Healthcare

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ABSTRACT

This PhD thesis examines the organizing of digital innovation in the healthcare sector, by drawing on process and practice-based approaches and by utilizing comparative field and longitudinal ethnographic methods, at three different hospital sites. Health care systems across the globe are under pressure, and digital innovation is seen as having tremendous potential and hope for transforming healthcare delivery. Digital innovation introduces a new, open-ended value landscape for generating or capturing value, which is integral to organizing.

The thesis examines the overarching question of *how to address the ongoing challenges of organizing for digital innovation at different stages of the process, including the underexplored allocation stage, as well as the usage and appropriation stages*. To do so, the thesis employs a novel theoretical framework that focuses on three specific areas of the phenomenon. First, to address the challenge of justifying and establishing the value of digital innovations, the first paper devises a performative framing perspective to examine how practitioners' temporally oriented framing practices matter in justifying and enacting different possibilities for reputational value. Value is conceptualized as fluid and mutable over time in the digital age.

The second paper examines how and why places are consequential for the scaling of the digital innovation of 3D printing, at the *usage stage*. By taking seriously the role of materiality in scaling, I propose a broader understanding of scaling as processes of place bending, framing and jumping, which are intertwined with considerations of resourcing, materiality and location meaning.

Finally, the third paper focuses on how occupations defend, contest and create boundaries at the implementation stage. The paper shows how the materiality of artifacts and spaces is constitutive of the way occupations mobilize, maintain and expand their jurisdictional boundaries. The dissertation concludes by discussing two overarching contributions that provide opportunities for future research.

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Last, but not least, I owe immense debts to my family and friends, whose support was crucial in this research endeavour. Mum and dad, thank you for encouraging and supporting me to pursue my dreams. In addition, my partner, Bryan Lim, has been a particularly important source of support, with whom I have had numerous intellectually stimulating conversations that have helped both challenge and support me write this thesis. I devote this thesis to my family and partner – I hope to continue making you proud and happy!

DECLARATION OF ORIGINALITY

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared here or specified in the text. I am the sole author of the Introduction and Conclusion chapters.

Paper 1 is co-authored with Professors Michael Barrett (second author), Eivor Oborn (third author), Oliver-Torsten Salge (fourth author), David Antons (fifth author) and finally, Rajiv Kohli (sixth author). Earlier versions of this paper won an AOM-OCIS Best Paper Proceedings Award (2016). The paper has been published in *Information & Organization* (https://doi.org/10.1016/j.infoandorg.2018.10.003). The published version has won the 2019 Meritorious Mention Paper Award (Junior Submission), by the Special Interest Group on IT in Healthcare of the Association for Information (AIS). In addition, the paper was finalist (among two other shortlisted papers in I&O) for the AIS Best Paper Award 2019. At least two thirds of the initial and original work are my own contribution.

Paper 2 is co-authored with Professors Michael Barrett (second author) and Eivor Oborn (third author). Earlier versions of this paper won the Best Paper Award for Track 14: IS in Organizations and Society, at the International Conference of Information Systems (ICIS 2016). The paper was nominated for the Most Innovative Research-in-Progress Paper at ICIS 2016. Moreover, a later version of the paper won a Best Paper Proceedings Award from the Academy of Management Annual Meeting (OCIS Division, 2020). Finally, we were invited to revise and resubmit the paper for publication at Organization Science (April 2020, Round 1-Special Issue on Emerging Technologies and Organizing). At least two thirds of the initial and original work are my own contribution.

Paper 3 is co-authored with Professors Michael Barrett (second author) and Samer Faraj (third author). Earlier versions of this paper won a Highly Commended Paper Award at the Organizational Behavior in Health Care (OBHC 2018) Conference and the AOM wide ITC Emerald Best International Symposium Award (2018) – 3D Printing and Beyond: Digital Innovation in a Physical World and its Implications. At least two thirds of the initial and original work are my own contribution.

In addition, this dissertation is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution. I further state that no substantial part of my dissertation has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University.

It does not exceed the prescribed word limit stipulated by Cambridge Judge Business School.

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INTRODUCTION

Health care systems across the globe are under pressure. In the US alone, medical spending in 2011 amounted to $2.7 trillion (Hartman et al. 2013), making the US healthcare sector the sixth largest "economy" in the world (Gaynor et al. 2015). Despite having one of the highest total health care expenditures as a percent of gross domestic product (OECD 2014), the growing US healthcare spending is not associated with better quality healthcare (Fisher et al. 2003a) or better health outcomes (Fisher et al. 2003b). Similarly, gaps within the English National Health Service (NHS) are becoming increasingly apparent (NIB 2014). According to the *Five Year Forward View*, unless health service delivery is reorganized by harnessing technology, patients' changing needs will go unmet, people will be harmed who should have been cured, and unacceptable variations in outcomes will persist (NHS England 2014).

Against this backdrop, digital innovation – the use of digital technology in a wide range of innovations, is seen as having tremendous potential and hope for transforming healthcare delivery through the broad and deep use of health information technologies (HIT) (Agarwal et al. 2010; Fichman et al. 2011). Enabled by an increasingly easy-to-use Internet, the digital infrastructures of computers and broadband network connections that collect, process, distribute, and utilize information, while accelerated by mobile computing technologies (Henfridsson and Yoo 2013) and social media platforms (Culnan et al. 2010), digital innovation allows for radically new (re)combinations of digital and physical components to produce novel products and services (Yoo et al. 2010). More specifically, digital innovation is the orchestration of new products, new processes, news services, platforms, or even new business models (Nambisan et al. 2017). Digital innovation, then, is argued to have the potential to improve care quality, while reducing costs (Institute of Medicine 2001; NIB 2014).

Perpetual Challenges in Innovating

However, significant challenges exist to realize these benefits, and the possibility of unintended consequences has been acknowledged. More broadly, digital innovations require changes in work (Bailey et al. 2012; Zammuto et al. 2007), challenges to occupational identity (Anteby et al. 2016; Nelson and Irwin 2014), as well as reconfigurations of jurisdictional boundaries (Barley 1986; Barrett et al. 2012). In addition, it is widely recognized that innovations are adapted as "unexpected technical evolutions, changes in user experiences or competitors' strategies" change innovations while being adopted (Akrich et al., 2002, p.214), thus warranting a processual view of innovation in the making (Garud et al. 2013).

Within healthcare, despite some notable exceptions (e.g. Angst et al. 2010), the digitization of innovation has proceeded less rapidly and less smoothly than in most other service sectors (Menachemi et al. 2006). The challenges are further exacerbated by the presence of strong regulatory requirements. Hospitals today operate in a highly regulated field (Agarwal et al. 2010; Scott et al. 2000) and rely on the endorsement of multiple external stakeholders, such as the Department of Health, regulatory bodies such as the Care Quality Commission, patient advocate groups and the media. In addition, the spread of innovations is an important theme in healthcare with the rise of the evidence-based medicine movement, according to which clinical practice should be based on rigorous evidence rather than on clinical opinion. This is reflected through the rapid growth of randomized control trials (RCTs), in which patients are randomly allocated to experimental and control groups. These regulatory requirements make establishing the value of digital innovations and their scaling extremely difficult. More specifically, justifying and assessing investments in digital technologies is particularly difficult. While there are indications that HIT investments pay off (Ayabakan et al. 2017), this is neither certain (Chiasson and Davidson 2004), nor short-term (Schryen, 2013).

Second, healthcare is a highly institutionalized environment regulated by government directives to change existing procedures and practices (Currie 2012; Mark 2007; Scott et al. 2000). This poses further challenges for justifying and implementing digital innovations. Research in the UK's National Health Service (NHS) has highlighted institutional pressures associated with the introduction of a national program for IT (NPfIT) between 2002 and 2012. Relatedly, this makes the dominant approaches to assessing HIT value - by focusing on operational and financial notions of value, inadequate for justifying value. In particular, research calls have been made to go beyond examining operational and financial performance post-hoc, towards exploring how HIT investments can enhance social goals, such as reputation – an intangible asset reflecting multidimensional evaluations held among stakeholders (Ravasi et al. 2018), at the allocation stage (Salge et al. 2015). Little is known about the initial allocation stage, during which senior managers decide how and how much of the organization's scarce financial resources should be allocated to digital innovation initiatives (ibid.). Healthcare practitioners are justifying HIT investments for reputational value that arises from the general social approval of various stakeholder groups (Rindova et al. 2005), which can influence operating autonomy, access to financial resources, and help in securing future patient referrals (Scott et al. 2000). Therefore, reputation is essential for hospitals in our digital era. Overall, the IT resource allocation decisions and their underpinning justifications are a crucial and

emerging area of research for holistically understanding the value of HIT across a wide range of economic and social goals, especially reputation.

Third, and related to the regulatory and institutional environment in health care, another major challenge for justifying and implementing digital innovations is scaling; how does an innovation scale from individual hospital units, to the rest of the hospital and the NHS? I define scaling as an emerging, deeply contextualized process situated in space and time, not just the "sizing-up" across different geographies, as Bansal et al., (2018) convincingly argue. This challenge is arguably one of the more urgent ones for the public sector, and for the NHS in particular, where regulatory mechanisms mandate scaling. Although digital technologies provide flexibility (Kallinikos et al. 2013; Svahn et al. 2017) that can be leveraged to rapidly scale digital ventures, we know less about the challenges of scaling in healthcare, given the unique challenges posed.

Thesis Motivation and Paper Development

Given the pervasive and enduring challenges facing healthcare organizations, this dissertation examines the major challenges of a) justifying and establishing the value of digital innovations at the allocation stage (cf. Salge et al., 2015), but also, b) when implementing them in practice – the usage stage (ibid.). The usage stage encompasses the set of activities whereby adopted digital innovations become an integral part of regular work practices. Digital innovation introduces a new, open-ended value landscape for generating and capturing value (Henfridsson et al. 2018). In order to tap into the potential of digital innovation for healthcare, hospital organizations need to justify the need for information technology (IT) investments, before proving the value of the innovation in practice. However, the dominant and enduring stream of literature in this domain has focused primarily on justifying value through a one-off and largely static outcome, by explicating and measuring operational and financial value dimensions of IT (Melville et al. 2004), post-hoc - in other words, after the investments have been made. In healthcare this is problematic as practitioners have historically faced great pressures in justifying health IT (HIT) investments (Currie 2012; Currie and Guah 2007).

Therefore, the first paper of the thesis builds on recent work that emphasizes the need to expand our understanding of the HIT investment process by focusing on the initial resource allocation stage (Salge et al. 2015), and by exploring and the multidimensional nature of IT value (Barrett et al. 2016; Tempini 2017). As such, the paper also complements and broadens the IT value literature for the digital age. I devise a performative understanding of the framing practices used to justify HIT reputational value, by theorizing how temporal orientations grounded in

value seeking approaches (reactive or proactive) and time horizons (short or long term) are continually performing multiple aspects of HIT reputational value. The paper's main contribution is to reconceptualize value as fluid and mutable over time in the digital age.

Another major challenge for digital innovations in healthcare, related to justifying and establishing value, is scaling. Overall, the digital innovation literature highlights that generativity (Zittrain 2006) and digital affordances can enable digital innovations to grow and scale rapidly in unprecedented ways (Henfridsson and Bygstad 2013; Huang et al. 2017). However, scaling in healthcare remains a crucial challenge, as the value of the innovation has to be established before it is implemented in practice, through ample clinical evidence. To understand this further, I examined an exemplary case of digital innovation, 3D printing, at a major teaching and trauma hospital. The second paper thus examines how digital innovations scale up across the organization at the usage stage. In particular, the paper highlights the continued importance of place in digital innovation. Digital is often meshed with physical materiality, thereby enabling, constraining, while being interwoven or entangled with human action (Orlikowski and Scott, 2008). By taking seriously the role of materiality in scaling, I propose a broader understanding of scaling as processes of place bending, framing and jumping, which are intertwined with considerations of resourcing, materiality and location meaning (e.g. power and politics).

Integral to the process of scaling are issues of occupational dynamics at the appropriation stage – which comprises those activities that enable organizations to translate the routine use of digital innovations into improved practices (cf. Salge et al., 2015). This requires aligning novel technologies and existing work routines (Barley, 1986), which may co-evolve over time (Davidson and Chismar, 2007). An implication of appropriating digital innovations, such as 3D printing, and reorganizing health service delivery, is the negotiation of medical professionals' occupational power and jurisdictional boundary reconfigurations (Abbott 1988; Barrett et al. 2012; Turner 1995). Therefore, the third and final paper of the thesis focuses on how the occupations involved in scaling the digital innovation of 3D printing mobilized, expanded or defended their jurisdictional boundaries. 3D printing requires collaboration amongst diverse occupational groups with different disciplinary, knowledge boundaries and expertise, embedded in a web of clinical fields, practice patterns and different technologies (Mol, 2002). In line with the practice turn in organization and management theory (Nicolini 2012; Schatzki et al. 2001), the paper engages with the notion of boundary work, defined as purposeful individual and collective effort to influence the social, symbolic, material, or temporal boundaries; demarcations; and distinctions affecting occupations (Langley et al.

2019). As such, examining the competitive boundary work, with a focus on how occupations *"defend, contest and create boundaries to distinguish themselves"* (ibid: 707) in order to defend, extend, or maintain their jurisdictions, provides a nuanced understanding of the process of scaling when a new technology is introduced at the workplace. Appropriating digital innovations, especially in healthcare, is challenging, as multiple occupational groups involved in multidisciplinary care, have idiosyncratic practices (Barett et al, 2012; Oborn et al., 2011).

Research Question

In the previous section, I have outlined the perpetual innovation challenges facing the healthcare sector, at different stages of the digital innovation process. By taking these insights into account, the overarching question for this thesis is:

How can we address the ongoing challenges of organizing for digital innovation at different stages of the process, including the underexplored allocation stage, as well as the usage and appropriation stages?

I investigate this overarching question by focusing on three specific areas of the phenomenon, each of which corresponds to three perpetual challenges identified above. Table 1 provides a summary. First, to address the challenge of justifying and establishing the value of digital innovations, I examine the underexplored allocation stage. To do so, paper 1 addresses the research questions of how practitioners justify HIT investments, and how these are consequential for enacting reputational value. Second, to address the challenge of scaling digital innovations at the usage stage, paper 2 examines how places matter in digital innovation and how they are consequential for scaling. Finally, paper 3 examines the occupational dynamics at the appropriation stage. Specifically, how occupations engage in competitive boundary work practices with the introduction of a new digital innovation in the workplace.

TABLE 1

THESIS OUTILINE

Perpetual Innovation Challenges	Stage	Papers	Research question
Justifying and establishing the value of digital innovations	Allocation	1	How do practitioners justify HIT investments and how are these justifications consequential for enacting reputational value?
Scaling digital innovations	Usage	2	How do places matter in digital innovation and with what implications for subsequent scaling?
Addressing occupational dynamics and changes in work with digital innovations	Appropriation	3	How do occupations engage in competitive boundary work practices with the introduction of a new digital innovation in the workplace?

Theoretical and Empirical Summary

The dissertation employs a practice perspective (Feldman and Orlikowski 2011; Nicolini 2012; Schatzki et al. 2001). All three papers provide a practice-based account of how value is enacted through framing practices (paper 1), how scaling is achieved through considerations of resourcing, materiality and location meaning (paper 2), as well as how boundary work practices are reconfiguring jurisdictional boundaries between occupation groups (paper 3). Theoretically, the thesis examines how justifying of HIT investments is achieved at the allocation stage (Polykarpou et al. 2018; Salge et al. 2015), addressing challenges when scaling them at the usage stage, and finally, how to overcome occupational dynamics challenges at the appropriation stage. Below I describe my methodological approach and empirical fieldwork.

The dissertation is comprised of three interrelated research papers. I utilize an inductive research design (Golden-Biddle and Locke 2007) and employ ethnographic (Van Maanen 2011) and process research methods (Garud et al. 2017; Langley 1999; Langley and Tsoukas 2016), to understand and unpack the complexities of the process of innovation (Garud et al.

2013). The fieldwork includes three different hospital sites over a period of five years. The research design is longitudinal and temporally interconnected across the research papers. This means that during the research process, themes emerged inductively, producing insights I had not foreseen at the start, which I temporally examined over time. Relatedly, I decided to pursue an ethnographic approach as an inductive way to study situations and phenomena, with the purpose of extending theory (Locke 2001). This aligns with my practice-based approach, which I further elaborate in each of the papers.

At first, I negotiated access to two hospital organizations that offered different dynamics for examining framing practices for justifying HIT. The first hospital case provided the opportunity of studying how practitioners were restoring reputation with HIT, following a regulatory inspection failure. In contrast, the second hospital enjoyed a leading reputation both nationally and internationally for high quality patient care, which practitioners were aiming to reproduce and enhance going forward. The novelty of the paper lies with examining the allocation stage of HIT investments, by adopting a temporal performative perspective on how justifying, as a process, enacts different value possibilities.

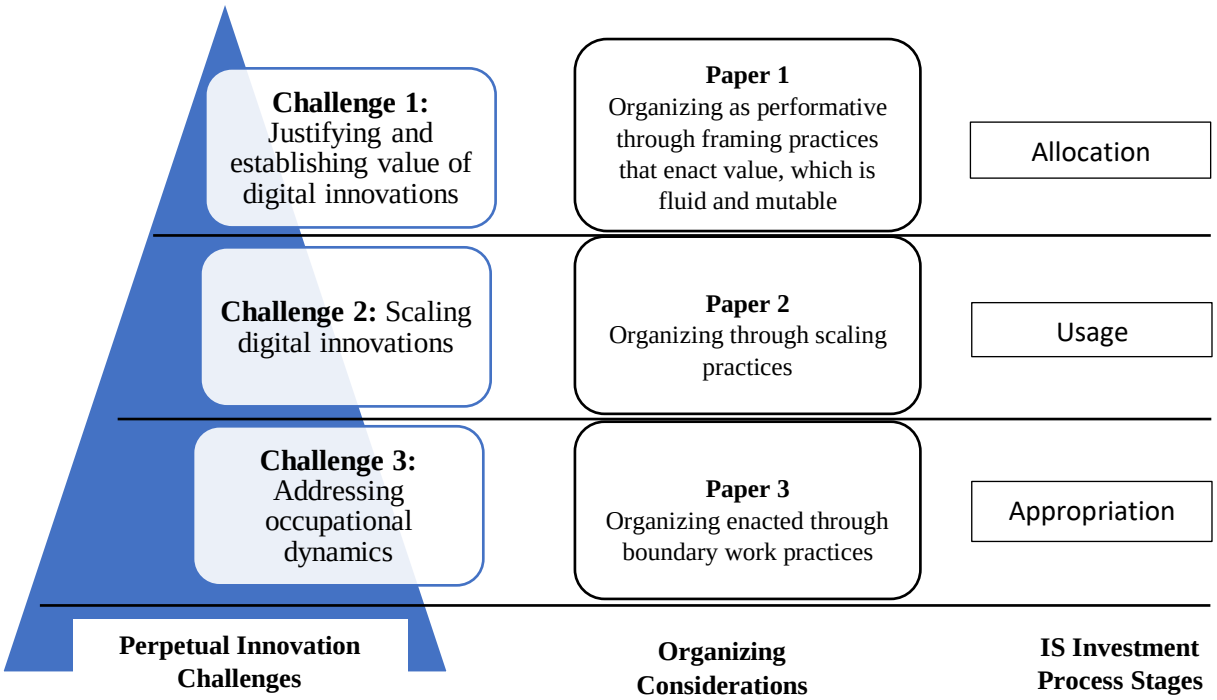
Although the first paper provided initial insights into the persistent healthcare challenge of justifying HIT investments at two different hospital sites, and how value is mutable, I decided to focus on a different hospital site and digital innovation altogether for empirically exploring the implementation stage. A significant opportunity arose at a hospital in the wider East Anglia region, which was implementing an in-house 3D printing lab and were attempting to scale this digital innovation across the hospital, local biomedical campus and, eventually, the East Anglia region and NHS more broadly. This provided a unique opportunity to study the phenomenon and challenge of scaling processualy, as I could empirically study the implementation and scaling of the innovation right from the start and as it was temporally unfolding over time. Soon thereafter, the role of place in scaling innovation emerged as an important insight for the process of scaling, which inspired the second paper of the thesis.

Finally, it also became clear that the role of occupational dynamics (Anteby et al. 2016) was crucial and consequential for implementing and scaling 3D printing. There is an established literature that shows how technological artifacts can transform work practices and reconfigure boundaries, as well as how the introduction and implementation of a new technology can challenge and change situated occupational roles (c.f (Leonardi and Barley 2010). The hospital case chosen provided fieldwork observations that were exemplary of the boundary work and jurisdictional reconfigurations occurred over time in the case of 3D printing (Barley 1986; Barrett et al. 2012). The paper contributes an understanding of how the wider materiality of

spaces and artifacts is constitutive of the way occupations mobilize, maintain and expand their jurisdictional boundaries, not just representational and subject to interpretation (cf. Bechky, 2003a). As such, we join studies paying attention to the materiality of boundary work which includes other organizational artifacts beyond boundary objects (Barrett et al., 2012; Lindberg, Walter, & Raviola, 2017), providing insights into organizing digital innovation.

Overall, I have devised an overarching theoretical framework that has guided my efforts throughout the completion of this thesis for organizing digital innovation. Figure 1 below visualizes the theoretical framework, which synthesizes the elements presented in table 1 above, that is, the perpetual innovation challenges in healthcare, alongside the IS investment process stages. At the intersection of the challenges and process stages, I outline the main theoretical insights of this thesis for organizing digital innovation. That is, how organizing is conceptualized and the implications for understanding digital innovation.

FIGURE 1
RESEARCH APPROACH: FRAMEWORK FOR ORGANISING DIGITAL INNOVATION



Source: Salge et al., (2015)

Thesis Outline: Organizing and Scaling Digital Innovations in Healthcare

Organizing is taking place in a world that is increasingly permeated with digital technologies such as Internet of Things, big data, mobile technologies and learning algorithms (Faraj, Pachidi and Sayegh, 2018), which are consequential and can transform work in unprecedented ways. There is an urgent need to conceptualize and study these phenomena, especially from a process and practice perspective, both of which focus attention on how organizing is entangled (Orlikowski and Scott, 2008) with emerging digital practices (Barrett et al, 2012; Vaast and Walsham, 2005), and how temporality is crucial in this process. Digital technologies are also transforming the physical and virtual places of work, both locally and globally. The role of geographically distant locales in shaping innovation resonates with recent research emphasizing the role of place in organizational work (De Vaujany and Vaast, 2013; Lawrence and Dover, 2015), and more specifically, trajectories of place in digital innovation (Oborn, Barrett, Orlikowski and Kim, 2019). Finally, organizing in the digital age raises new opportunities as well as unexpected challenges. For example, digital innovation may bring exclusionary consequences for transforming work, bring about novel actors, structures, practices, values and beliefs that change, replace or threaten existing arrangements (Hinings, Gegenhuber and Greenwood, 2018).

The following three papers thus offer a process and practice-based account of how some of the most persistent challenges of justifying and implementing digital innovation in healthcare can be addressed, in the digital age. At the same time, the papers also seek to provide a helpful reframing of these challenges and a different perspective for addressing them, hence contributing to our understanding of organizing and scaling digital innovations in healthcare. As such, the dissertation is positioned at the intersection of technology, digital innovation, work and organizing.

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Paper One

Justifying Health IT Investments: A Process Model of Framing Practices and Reputational Value

ABSTRACT

For more than two decades, IT value research has made important contributions to a fundamental topic in information systems scholarship, that is, how organizations are able to justify and create value from IT investments. Recent work has challenged static and narrow views of value as only financial and operation, highlighting the importance to understanding value as articulated across multiple dimensions. Building on these developments, I adopt a performative perspective to examine the research question of how practitioners justify early stage HIT investments, with a focus on reputational value. We explored this question through a comparative field study of two hospital organizations in the English National Health Service (NHS). We found that practitioners' temporally orientated framing practices matter in justifying HIT investments, enacting different possibilities for reputational value. We develop a process model to explain these dynamics and highlight the mutability of reputational value, which can lead to different possibilities for restoring, enhancing, or maintaining reputation. We conclude by discussing the implications for justifying HIT investments.

Keywords: IT business value; IT investments, Health IT; health care; value; case study; reputation; framing practices; performativity

For more than two decades, information technology (IT) value research has made important contributions to a fundamental topic in our field, namely how organizations justify and create value from IT investments (Agarwal & Lucas, 2005; Kohli & Grover, 2008). The dominant and enduring stream of literature in this domain has focused primarily on justifying value through a one-off and largely static outcome, by explicating and measuring operational and financial value dimensions of IT (Melville, Kraemer, & Gurbaxani, 2004). Further, the approach taken has been predominantly to assess the value of IT investments post hoc - in other words, *after* the investments have been made. In healthcare this is problematic as practitioners have historically faced great pressures in justifying health IT (HIT) investments, where institutional pressures are at work. For example, research in the UK's National Health Service (NHS) has highlighted institutional pressures associated with the introduction of a national program for IT between 2002 and 2012 in the UK's NHS (Currie 2012; Currie & Guah, 2007; Mark, 2007). While there are indications that HIT investments pay off (Ayabakan, Bardhan & Zheng, 2017; Lin, Chen, Brown, Li, & Yang, 2017) this is neither certain (Davidson & Chiasson, 2005) nor short-term (Schryen, 2013), thus making HIT investments hard to justify and to appropriately assess.

Recent work has emphasized the need to expand our understanding of the HIT investment process by focusing on the initial resource allocation stage (Salge, Kohli, & Barrett, 2015) and by exploring the multidimensional nature of IT value (Barrett, Oborn, & Orlikowski, 2016; Tempini, 2017) as an important complement to the dominant view of value. In particular, relating economic and operational notions of value to other dimensions has formed a stronger basis for understanding the importance of value as a concept (Stark, 2009). We know, for example, that HIT investments can provide multiple forms of value for different stakeholders, such as reputational, epistemic and platform value among others (Barrett et al., 2016) and that these develop in a nonlinear and contingent trajectory (Tempini, 2017). Yet, while these studies have provided important contributions, by examining how HIT investments provide opportunities for value creation along multiple dimensions, our understanding of how investments are justified in practice during the allocation stage is largely an incomplete task. The purpose of this paper is therefore to respond to a call for a broader HIT research agenda that moves beyond examining operational and financial performance post-hoc, towards exploring how HIT investments can enhance social goals, such as reputation – an intangible asset reflecting multidimensional evaluations held among stakeholders (Ravasi, Rindova, Etter & Cornelissen, 2018), at the allocation stage (Salge et al., 2015). Healthcare practitioners are justifying HIT investments for reputational value that arises from the general social approval

of various stakeholder groups (Rindova, Williamson, Petkova, & Sever, 2005), which in turn can influence operating autonomy, access to financial resources, and help in securing future patient referrals (Scott et al., 2000). For these reasons, we shift to a proactive approach to examine how healthcare practitioners are framing and evaluating HIT investments with a broader social focus on reputational value. We therefore examine the research question *how do practitioners justify HIT investments, and how are these justifications consequential for enacting reputational value?*

To address our research question, we present findings of two case studies at hospital organizations facing different reputational circumstances. The first hospital provided the opportunity of studying how practitioners were restoring reputation with HIT, following a regulatory inspection failure. In contrast, the second hospital enjoys a leading reputation both nationally and internationally for high quality patient care, which practitioners were aiming to reproduce and enhance going forward. Our paper makes two key contributions. First, we develop a process model that unpacks how practitioners justify HIT investments through framing practices. Responding to Davidson's (2006) call, we develop a performative perspective on framing practices, by which justification of HIT investments is accomplished. We define performativity as the dynamic processes and practices that co-constitute the realities they ostensibly describe (Gond, Cabantous, Harding et al., 2015). In our case, we find that temporally oriented framing practices in terms of time horizon (short or long term) and value seeking approach (reactive or proactive), enact different possibilities for reputational value. We conceptualize framing practices as performative in that they involve both the creation and emergence of different aspects of value, informed by the past, but also oriented toward the future and the present. Second, we highlight how the justifying of HIT investments is an ongoing process which enacts reputational value that is nevertheless mutable over time, with implications for how reputation is restored, enhanced, or maintained. In the following section, we review different perspectives on justifying IT investments, such as the initial IT allocation stage, and motivate our theoretical and empirical focus on reputational value. This is followed by our theoretical basis which develops a performative HIT value perspective.

PERSPECTIVES ON JUSTIFYING HIT INVESTMENTS

Examining the initial IT allocation stage

There is considerable literature in general IT and HIT (Grover & Kohli, 2012; Kohli & Devaraj, 2003; Melville et al., 2004) that focuses on the importance of examining the process of

investing in IT. Scholars have examined, for example, IT adoption (Agarwal et al., 2010; Jha et al., 2009), IT usage (Devaraj & Kohli, 2003; Melville et al., 2004), and IT value appropriation (Davidson & Chismar, 2007; Oborn, Barrett, & Davidson, 2011), thereby justifying the value of IT investments. However, studies in this research stream tend to treat IT investments as "given", unitary and unchanging, with the primary emphasis placed on evaluating the consequences of IT investments. Recent work by Salge et al., (2015) has expanded the process spectrum of IT investment research to encompass the initial allocation stage, during which senior managers decide how and how much of the organization's scarce financial resources may be allocated to the IT function, in the face of competing priorities (Xue, Liang, & Boulton, 2008). Their study reveals that intended performance improvements are only just one of several reasons why hospitals invest in HIT. They conclude by calling for a broader HIT research agenda that moves beyond examining clinical and economic performance as important dimensions, towards exploring how HIT investments can enhance social goals such as reputation (Bitektine, 2011).

Reputation has been defined as an impression widely received, which represents public cumulative judgments over time (Fombrun, 1996; Hall, 1992; Rao, 1994). Organizational reputation is an important form of social approval and a critical intangible resource of competitive advantage that can facilitate access to customers, employees, suppliers, or finance (Deephouse, 2000; Fombrun & Shanley, 1990; Lange, Lee, & Dai, 2011; Ravasi et al., 2018). Multiple studies show the importance of reputation for organizations as a valuable strategic resource, leading to positive economic outcomes such as financial performance (Roberts & Dowling, 2002) and the ability to charge premium prices (Fombrun & Shanley, 1990; Rindova et al., 2015). Reputation is critically important for organizations in general (Podolny, 2005) and hospitals in particular (Scott et al., 2000). For example, hospitals today operate in a highly regulated field (Agarwal, Gao, DesRoches & Jha, 2010; Scott, Ruef, Mendel, & Caronna, 2000) and rely on the endorsement of multiple external stakeholders, including the Department of Health, regulatory bodies such as the Care Quality Commission, patient advocate groups and the media to operate. All these stakeholders are constantly assessing hospitals and HIT enabled care in the form of patient feedback, national audits, quality inspections and news stories, respectively (Ruef & Scott, 1998). Therefore, reputation is essential for hospitals in our digital era. Overall, the IT resource allocation decisions and their underpinning justifications are a crucial and emerging area of research for holistically understanding the value of HIT across a wide range of economic and social goals, especially reputation.

Realizing multiple value dimensions

The broadening of the HIT value literature aligns with key themes in the emerging stream of information systems research that examines multiple dimensions of value. For example, Barrett, Oborn, & Orlikowski (2016) examine multiple forms of value being enacted in an online healthcare community. Drawing from the sociology of worth literature (Boltanski & Thévenot, 2006; Stark, 2009), they conceptualize valuation processes as shaped by encompassing regimes of worth that enact multiple kinds of value such as financial, epistemic, ethical, service and reputational value. Similarly, Tempini (2017) builds on and develops a multidimensional value framework to examine business value, scientific value, community value and individual value, all of which had different informational value depending on situated use.

By taking these insights into account, we are interested in elaborating theory as to how practitioners justify and enact multiple dimensions of reputational value. Reputational research shows that IT can provide other value, such as organizational survival and social fitness (Lim, Stratopoulos, & Wirjanto, 2013). For instance, Wang (2010) found that following IT fashions – "the transitory collective belief that an IT is new, efficient, and at the forefront of practice" (p.64), can improve organizational reputation, even in the absence of performance improvement. Although these studies have crucially expanded our understanding of value that IT investments can provide, they largely view value as a one-off, static outcome. That is, reputational value is conceptualized as either the intrinsic property of IT, or the preferences of the evaluative audiences. This is problematic because reputation is a multi-dimensional concept (Boutinot, Ansari, Belkhouja, & Mangematin, 2015; Lange et al., 2011) and multiple reputational assessments may change over time. In this paper we unpack how senior healthcare practitioners allocate various possible forms of reputational value into their HIT investment justifications. We do so by considering how the various stakeholders are framing HIT investments.

THEORETICAL FRAMEWORK: TOWARDS A PERFORMATIVE PERSPECTIVE OF FRAMING HIT INVESTMENTS

We devise a theoretical framework that conceptualizes HIT value as performed through framing practices. As such, in examining how HIT investments are justified, we pay attention to the way in which justifications are accomplished, and how HIT value is constituted through framing practices. We identify the practices that are constitutive of, and implicated in, performing shared understandings of justifying HIT investments. In so doing, we conceptualize

the phenomenon of value as fluid and enacted in the doings of organizational actors (Feldman & Orlikowski, 2011).

The performativity turn is comprised of a diverse body of foundational approaches and generative theories for studying diverse phenomena across disciplines. The performative turn is unified in arguing that realities (including objects/subjects) and representations of these realities are being enacted or performed simultaneously. In other words, and to paraphrase Strum & Latour (1987), phenomena (in our case reputational value) are continuously constructed through the heterogeneous efforts to define them in practice.

Framing HIT Value

Organizational members' frames "concern the assumptions, expectations, and knowledge they use to understand technology in organizations" (Orlikowski & Gash, 1994, p. 178). More broadly, scholarship on framing (Barrett, Heracleous, & Walsham, 2013) has identified several aspects of framing practices that are important, based on the literature on social movements (Benford & Snow, 2000) and computerization movements (Iacono & Kling, 2001; Kling & Iacono, 1995). These and other studies have highlighted the importance of a processual view of technological *framing*. For instance, Davidson (2002) developed business value of IT frame domains which were concerned with members' understanding of how IT could be used to alter business processes and relationships. By doing so, Davidson contributed by providing a process model that draws attention to the dynamics and possible consequences of frame shifts.

Our perspective uses framing practices, which concern the material and discursive manner by which justifications are accomplished, with an orientation of accounting for how justification is done in practice. This implies framing practices are routinely made and remade in practice and are consequential to shared understandings of reputational value. The concept of performative framing is related to Davidson's (2006) call to IT researchers to focus on the dynamic aspects of the framing process. That is, framing practices are performative in that they involve both the creation and emergence of different aspects of value. In our case this helps us unpack the multiplicity of how reputational value can be enacted, rather than assuming a priori value singularity. For instance, ongoing framing practices may make evident the diverse aspects of reputational value.

Temporally Performing HIT Justifications

Further, our performative perspective allows us to take seriously the role of temporality (Emirbayer & Mische, 1998; Langley, Smallman, Tsoukas & Van de Ven, 2013; Reinecke & Ansari, 2017) in the process of justifying HIT investments. As Emirbayer & Mishe argue

(1998), agency is a temporally embedded process informed by the past, but also oriented toward the future and toward the present. In other words, acting in the present is extended and overlapping with our ability to imaginatively construct a sense of the past and the future. Following these process insights (Langley & Tsoukas, 2017), our framework examines how temporal orientations – the interpretations and invocations of time horizons (short or long term) and value seeking approaches (reactive or proactive) - influence how reputational value is framed in the process of justifying HIT investments. Specifically, we link the reactive value seeking approach to the short-term time horizon, which tends to be focused more towards the past and the present. On the other hand, a proactive value seeking approach tends to be focused on the future and the present. However, these are not universal truths and do not preclude the potential for a temporal orientation having a broader focus at particular times and situations.

As illustrated by Kaplan & Orlikowski (2012), people are engaging in multiple interpretations that help constitute projections into the future, such as the short term or long term, and we draw on this to suggest how these might link to reputation. In other words, we pay attention to how healthcare practitioners are justifying HIT investments and what difference the time horizon and value seeking approach have in framing reputational value. Finally, and relatedly, we conceptualize reputational value as not a one-off outcome; rather, value dimensions are viewed to be mutable over time.

In summary, we develop a performative understanding of the framing practices used to justify HIT reputational value, in that we theorize how temporal orientations grounded in value seeking approaches (reactive or proactive) and time horizons (short or long term) were continually performing multiple aspects of HIT reputational value.

METHODS AND DATA SOURCES

We followed an inductive research design and adopted an interpretive approach (Golden-Biddle & Locke, 2007; Walsham, 1993), starting from an interest in how organizational participants engaged in framing practices when justifying HIT reputational value. Informed by a process approach (Langley, 1999), we collected data at two different hospitals, which are both members of a common health group we call Alpha Health Partners (AHP).

Research context

Our two cases offer different dynamics in relation to our research question, which provided fertile ground for examining framing practices for justifying HIT investments. AHP1 provides mental health and specialist community services to more than 755,000 people across the

country. With annual income of more than £150 million, AHP1 employ 2,500 people across 75 sites. They service children, adolescents, adults, older people, as well as provide specialist forensic and learning disability services. AHP1 provided the opportunity of studying how the hospital organization was restoring reputation with HIT, following a regulatory inspection failure. During their usual hospital regulatory audit, the regulators issued a warning which placed the hospital under pressure to restore and repair their reputation. In contrast, AHP2 enjoys a leading reputation both nationally and internationally for its services and for high quality patient care. AHP2 is a specialist hospital that provides care to approximately 3 million people. During the time of our study, AHP2 was justifying HIT investments as part of major move to a new hospital site, to replace their outdated building and infrastructure, which was constricting their ability to grow and develop the way they envisioned. A major part of this move was a business transformation program they called eHospital, which is a combination of IT infrastructure, handheld devices and a fully integrated electronic medical record system (EMR), defined as the digital repository of patient data that is shareable across stakeholders (Angst et al., 2010).

Data collection

We collected data from a variety of sources over a period of 3 years, including site visits, observations during meetings, formal interviews, informal discussions, and publicly available documents. First, we engaged with AHP1 before, during and after their regulatory inspection by the care quality commission (CQC). We conducted 14 semi-structured interviews to better understand a) the situation they were facing, b) the future requirements of mental health, as part of their digital strategy, and c) how they were justifying HIT investments and implementing these investments in practice. The interviews were conducted on-site in 2014, with participants from a diverse range of backgrounds, different hierarchical levels and service provisions (chief executive officer, chief nursing officer, chief pharmacist, nursing, medical and finance directors, nursing manager, patient lead, nurse matron, deputy finance executive, clinical psychologist, consultant psychiatrist, psychology lecturer, audit and governance manager). Subsequently, we had the opportunity to engage with the technology director at AHP2, who was keen to collaborate with us. Similar to AHP1, we conducted 13 semi-structured interviews on-site between 2015 and 2016, with participants from a diverse range of backgrounds (operations and service improvement directors, senior level managers of communications, change, IT and radiology, transplant consultant, consultant cardiologist, consultant physician, consultant anesthetic, transplant matron, clinical lead for eHospital, and a nurse lead - eHospital coordinator). Across both cases, our interviews provided multiple

understandings and accounts of the framing practices used and allowed us to examine not only how management were framing HIT investments, but also how HIT was implemented by staff on the ground. The interviews varied in length, ranging from 35 to 120 minutes. All interviews were digitally recorded and subsequently professionally transcribed, verbatim.

Our interview questions focused on understanding the practices through which our organizational participants were justifying HIT investments and how they were implemented, given their circumstances in the context of their work. For example, we asked how they were using different types of HIT to complete their work, how they envisioned HIT would provide value in the work setting. In addition, we collected and analyzed secondary data sources. These included informal chats, internal documents (e.g. operational, strategy and annual reports, presentations, newsletters, images,) as well as archival and documentary data (e.g. healthcare commissioning guidelines, regulator reports including hospital performance intelligence monitoring guidelines, and hospital rankings), leading to a database of 85 documents.

Data analysis

Our analysis followed the general procedures of process analysis (Langley, 1999) to expand our understanding of how healthcare practitioners were justifying HIT investments. Throughout all the different stages of analysis, we used Atlas.ti, a qualitative data analysis software package, to create an integrated database. This facilitated the generation of rich memos and open codes across the two cases, as well as the development and tracking of coding categories.

The first cycle of analysis involved a narrative strategy, where we constructed a detailed narrative for each case based on our interview transcripts, hospital annual and regulator reports and internal documents (Langley, 1999). Subsequently, we performed open coding (Charmaz, 2014) to unpack the framing practices used in justifying HIT investments. To do so, we engaged in within-case analysis to become familiar with each case, enabling us to write further detailed narratives for each case, based on extensive theoretical memos on our emerging findings. To keep track of the unfolding analysis, we compiled an event-history database in Atlas.ti throughout the fieldwork. This enabled the unique patterns of each case to emerge in terms of temporal framing practices, before we attempted to apply insights across the cases, facilitating familiarity and accelerating the cross-case comparison. It is important to note that the importance of framing practices emerged as a key theme in justifying HIT investments across both our cases, and this reinforces the significance of our research design in studying both cases.

In a second cycle of analysis, we identified how these framing practices, within and across our cases, were performing shared understandings of HIT value, with a focus on our inductive data around reputational value. In this round of analysis, we iterated among the in-depth analysis of each case, comparing across cases, and connections to the literature (Barrett et al., 2016; Kornberger, 2017; Tempini, 2017), which drew our attention to other salient issues emerging from the data that were unexplored. For example, while we connected the framing practices to HIT reputational value, we also realized the importance of different temporal orientations found within each case, in terms of the time horizon.

Having recognized this opportunity, and during a third round of analysis, we examined the temporal orientation of each of the practices we identified in round two, following our theoretical framework. While our sensitivity around time horizon was theoretically driven, the analysis of the framing practices in terms of reactive or proactive value seeking approach was grounded in our data. In this round of analysis, we traced and explained the performative dynamics of how temporal orientations mattered when enacting framing practices in the ongoing justifying of HIT investments. This allowed us to categorize the framing practices practitioners used at AHP1 and AHP2 as helping to overcome issues of the past, resolving present issues, whilst being oriented towards the future. For example, the aggregate dimension of "overcoming the past" refers to the practices anchored in solving past problems, "present issues" provides the tactical practices anchored in short-term horizons, and finally, we categorized strategic practices anchored in long-term horizons under the dimension of "towards the future". Figure 1 shows how we categorize the practices under the temporal aggregate dimensions and according to short/long term horizon as well as reactive/proactive value seeking approach.

----------Insert Figure 1----------

Additionally, we paid attention to how framing practices were invoking multiple value aspects and stakeholders, such as convincing regulators during inspections, improving relations with commissioners, hospital staff, general practitioners (GPs), patients and other referring hospitals. This allowed us to develop a performative understanding (MacKenzie & Millo, 2003) of how practitioners were using framing practices in the process of justifying HIT reputational value at AHP1 and AHP2. We theorize how temporally oriented framing practices informed by the past but also oriented toward the present and future issues were justifying multiple HIT reputational value aspects, invoking different stakeholder groups.

FINDINGS AND ANALYSIS

We present our findings for each case separately. We begin by describing the circumstances facing each of our hospital organizations, which are consequential for the temporally oriented framing practices performed by the senior managers and practitioners. We then show how framing practices at AHP1 and AHP2 were used in performing different justifications of HIT reputational value. Finally, drawing on these empirical findings across our cases, we conclude our empirical analysis by synthesizing our findings in a general process model of framing practices and reputational value in justifying HIT investments in healthcare.

AHP1: Restoring reputation through HIT

To understand how practitioners at AHP1 enacted their temporally oriented framing practices for reputational value, it is necessary to examine the pressures they faced and their ensuing temporal orientation. In 2011, the care quality commission (CQC)– the independent regulator of health and social care in England, found AHP1 to be failing to meet the five essential standards during its annual compliance review process. CQC inspects hospitals to establish whether their services are safe, effective, well led, responsive to people's needs, as well as whether staff is caring. By exercising its legal right, the regulator demanded action from AHP1 to conform to effective care quality and patient safety standards. Following the specification of this major organizational failing, AHP1 practitioners were justifying HIT investments using both short-term and long-term time horizons, as well as reactive and proactive value seeking approaches, to quickly implement HIT that would help them restore their reputation, but also help them proactively appeal to different stakeholder groups, respectively. Figure 2 summarizes our empirical findings and structures our analysis, while table 1 provides additional evidence for the time horizon and value seeking approach of the temporally oriented framing practices.

----------Insert Figure 2----------

---------- Insert Table 1 ----------

Overcoming the past: Crafting urgency for restoring reputation with HIT

The failure to meet the regulatory compliance standards by CQC, led AHP1 senior managers and directors to justify HIT investments as urgently needed for collecting, storing, and visualizing data to CQC in an accessible manner. Their aim was to improve the quality, safety and effectiveness at the point of care delivery. A nurse matron responsible for implementing this HIT reflected on this process:

"There was just this mad rush for everything, everything you know to do with IT, where we can make these dashboards, make everything very visual so it is at a glance, everything was red, green or amber, nobody wanted to attract a red. Red was like blood, animal pack attack. You know not a pretty picture".

Furthermore, AHP1 executives framed HIT investments as helping the hospital devise an internal quality assurance framework that would allow clinical teams to self-assess against CQC measures of compliance, at the point of delivery. The aim of this strategy was to restore their reputation in the CQC rankings. Each clinical team was required to maintain a portfolio of evidence provided by HIT dashboards, which would support CQC compliance measurements. With this framing practice, the practitioners argued HIT would help them rigorously test and review local evidence of how each compliance measure was being assessed. By identifying the problem as needing immediate evidence of CQC compliance, while reflecting on a reactive temporal orientation, their framing practice introduced a sense of urgency for restoring reputation with HIT.

Present issues: Investing in HIT to display professional information handling processes

AHP1 practitioners also sought to legitimize the use of EMR information as beneficial in quantifying the metrics CQC is seeking during their inspection process. As such, HIT was framed as helping them restore their reputation by articulating solutions and action plans. For instance, the director of finance highlighted the importance of storing and presenting EMR patient information for enhancing regulatory compliance, by giving the impression that they are "more professional than just rooting around for the odd note":

"CQC like to come and visit, review and you log onto the [EMR] system and see how information is stored and kept, it is important that whatever system we use complies with the appropriate governance, that we store all the information we need on the system, so when they turn up it is all very clear and they are not having to go to this drawer for that piece of information… the benefit of the EMR, then, is that they can come in, log onto a patient's record and see patients' physical health, their daily actions, their drugs, they can just see it on one screen… the EMR helps us prove that quicker and we are more professional than just rooting around for the odd note".

Although EMR information was crucial, AHP1 were also framing mobile applications as important in helping them convince CQC of their compliance, by enabling the monthly tracking and evaluation of compliance targets through real time digital scores:

"There is a range of CQC compliance standards that we have to comply… we have created an iPad assessment tool that all of our teams have to complete monthly and every question then is allocated to an outcome, a CQC standard".

In addition, AHP1 practitioners were invoking other stakeholder groups in their justifications of HIT investments. For instance, they framed the use of EMR information as helping them convince commissioners of increased health care service activity levels, gain access to further funding and improve their overall negotiating position with them. In this way, the use of EMR information was framed as providing reputational value through the power of commanding resources, such as funding with commissioners. As reflected in the quote below by the CEO of AHP1, EMR information was framed as being a "weapon in the armory" for contract negotiation with commissioners:

"It is not just commissioning in terms of the financial elements […], it is also about the information as a weapon in our armory around contract negotiation. This is an important element of what we would use an information system for".

The CEO of the organization framed EMR use as affording information that could provide a better negotiating position with commissioner groups. HIT was crucial for AHP1, especially in the context of mental healthcare, as hospitals receive funding under block contracting. In this contract type, commissioners pay mental health service providers an annual fee in instalments, in return for providing a defined range of services over a fixed period. However, AHP1 had been spending more money than provided by the fixed contract amount due to increased patient activity. The CEO of the hospital shared that the only way they could access further funding was by evidencing this increase in activity through information, something they have had real difficulties doing so in the past, therefore leaving the hospital financially strapped. Through several discussions with the commissioner groups, the hospital senior management team were aware that commissioners get frustrated and remain skeptical with the lack of information, because then they think the hospital is trying to hide something just to take their money. In short, senior managers were invoking the importance of the mental healthcare funding context, to justify investing in HIT to display professional information handling processes. This was to motivate their framing practice in terms of lack of transparency for the commissioners, which made their funding evaluations more difficult – hence making the collecting, storing and using of information as a signal of good decision making.

Towards the future: Investing in HIT to improve relationships with key stakeholders

On the other hand, during the period of the CQC crisis, contrary to their primary temporal focus, a more future oriented dimension was also noted. For example, HIT was framed as having "substantial benefits to stakeholder relations", such as improving existing relationships with CQC, GPs, research organizations and their own research staff. For instance, the CEO argued that utilizing EMR anonymized patient information would help AHP1 engage with other key research hospitals in the wider ecosystem:

"We have got a very strong research base in the [hospital]… we use information a lot and we have been able to produce some very striking insights about death rates amongst people with schizophrenia by looking at meta data ['data about data']. What we would be able to do is enhance our reputation there is no doubt about it".

More specifically, senior managers at AHP1 stressed the importance of 'granular' information for building better relationships with their GP stakeholders. For example, the COO commented on how information can improve relationships with GPs:

"The other thing for me is the type of information that I would have to share with stakeholders… obviously with the GPs, I would have had a good understanding of market analysis, where, what sort of market share I had, I'd be able to go and target GPs who stopped referring [patients] to my organization, and so actually the information in itself, takes you out of the organization, and starts a really intelligent conversation with the GPs".

The above quote demonstrates the importance of GPs for hospitals. GPs increasingly have greater involvement and influence when referring patients to hospitals. Investing in HIT was framed as a way to better engage with this stakeholder group through the provision of granular level patient data instantly and remotely. This was an issue which many practitioners at AHP1 thought was crucial for reputation. The chief pharmacist commented that "in terms of reputation…GPs value clear and quick information from us at the time of discharge". Similarly, the deputy director of finance noted that GPs tend to seek "micro [detailed] data about patients from their micro perspective". This was very important for AHP1, given the "poor relations mental health hospitals have with GPs", often on the bases of the "lack of professional information" and their "inability to access patient data remotely during meetings" (Deputy Finance Director).

Relatedly, they framed HIT as a potentially attracting and retaining factor for hospital staff. The chief pharmacist emphasized that "*if people are seen to be embracing new technology, then you are seen as a forward-thinking organization and people want to work for you"*. In this way, AHP1 practitioners framed HIT investments as improving relations with key stakeholders

relatively quickly, enabling them to restore their reputation by invoking other stakeholder groups. Their temporal orientation influenced their framing practices such that HIT was a means to an end; a way to convince their stakeholders of the rationality of their decision making and to impress with visual dashboards, irrespective of actual decision improvements. Through their framing practices, they were performing new justifications of HIT value for diverse aspects of reputational HIT value for different stakeholders.

Restoring HIT reputational value

The temporally oriented framing practices were key at AHP1, as they helped the hospital mobilize after the critical CQC inspection and eventually to restore their reputation with the regulator. Through their framing practices, their ongoing justifications for using and investing in HIT were framing different aspects of reputational value for diverse stakeholders. For example, the short-term, reactive value seeking practices justified the urgent need for AHP1 to develop their own mobile applications to enable the monthly tracking and evaluation of CQC compliance targets, through real time digital scores. More specifically, they created a tablet-based assessment tool that all their care teams had to complete monthly were based on questions allocated to CQC outcomes and standards. All the data collected were fed into a governance dashboard that produced visual charts around a wide range of CQC outcomes. Throughout a period of rapid changes in relation to IT based mechanisms for assuring quality, they convinced the CQC that they met the standards and restored their reputation. In their inspection report in 2013, CQC praised patient care at AHP1 for being "fully compliant in key CQC areas" and lifted the 'special measures' the hospital had been facing.

AHP: Enhancing and maintaining reputation through HIT

AHP2 is a leading hospital that enjoys an international reputation for clinical excellence and innovation. Practitioners at AHP2 had an overall orientation towards the future, by using mostly long-term and proactive value seeking approaches with a view of investing in HIT to maintain and enhance their reputation. As such, the framing practices used were concerned with reimagining their future as a "digital hospital without walls". Their vision, articulated in their HIT strategy document, was as follows:

"Our vision is to deliver a 'hospital without walls'. Where world renowned, specialist care can be provided at the right time in the right location enabled by high quality, flexible HIT that provides a single source of clinical information, supports patient choice and empowerment and enables staff to do exceptional work through access to the right technology and information".

Although AHP2 were subject to audits, inspections, assessments, and rankings from regulators, similar to AHP1, they were not bounded by their present concerns and pressure in justifying HIT investments. Therefore, their proactive temporal orientation influenced their framing practices by giving them open time horizons to appeal to the future needs of the hospital. We summarize our case findings in figure 3. Table 2 provides supporting evidence for the framing practices enhancing reputational value at AHP2.

----------Insert Figure 3----------

---------- Insert Table 2 ----------

Towards the future: Envisioning national and local strategies

AHP2 practitioners were framing key contributions that HIT investments would make to enable the hospital to respond to local and national strategic drivers. First, they were envisioning a future where they would appeal to the national strategic context of the UK by investing in HIT. For instance, they were invoking the National Information Board's framework for action (2014), which was providing details as to how data and technology will support the delivery of the Five-Year Forward View (NHS England, 2014). As such, they appealed to the technology-focused national healthcare strategy to proactively identify their present situation and envisioned a future where HIT is key to their success, as communicated in their HIT strategy:

"HIT needs to support the hospital in responding to national strategic initiatives through delivering systems and infrastructure that directly support the delivery of high quality care at every stage of the patient journey regardless of location, as well as the creation of open, transparent, accessible data that can be used intelligently to become proactive, not reactive, and drive accurate business decisions based on integrated real-time information".

Second, by reimagining the future through responding to the local strategic context, they framed investing in HIT as supporting them in maintaining and building further their worldwide recognition for care, training, and research. Relatedly, leaders at AHP2 were framing HIT investments in the present as supporting the future vision of their "digital hospital without walls". As part of their framing, they highlighted the importance of moving to a new hospital site:

"The move to [the new hospital site] is a once in a lifetime opportunity for the hospital to create a truly digital hospital that delivers exceptional patient care and staff experience".

To do so, they framed HIT investments as supporting personalized, patient centered healthcare

and the provision of integrated systems that would provide fast, reliable information and data for both management and research purposes. Additionally, they highlighted the importance of how HIT would support them in providing safe and high-quality care, by enabling them to capture, monitor and audit clinical information electronically. Overall, their proactive, long term temporal orientation influenced their framing practices by helping in justifying and identifying long term benefits from HIT investments.

Towards the future: Investing in HIT to create strong business partnerships and relationships

As part of their framing practices, AHP2 justified HIT investments as the way to create strong business partnerships and relationships with their key stakeholders. The technology director explained:

"So one of the golden threads in realizing the HIT strategy is we can't do it on our own, we don't have the knowledge, the expertise, […] what we have is our reputation for clinical excellence and innovation, so one of the things that I'm keen to build is that we bring the two parties together and we form strategic partnerships to do the clever stuff".

Apart from helping them engage in strategic partnerships, AHP2 practitioners enrolled diverse stakeholders whom HIT would allow them to connect with. One of these groups is the funding commissioners, as explained by the technology director:

"Technology may help us with commissioners too, because we'll have more granular information about all of our interventions, how much they cost and how long they take, so the data that we can extract from our technical solutions become a selling mechanism in themselves".

In addition to commissioners, another key stakeholder group enrolled in their framing practices were other referring hospitals. They framed HIT as helping them improve their waiting lists for patients and delivery care, which they envisioned would influence hospital referrers. In the words of the technology director:

"One of the expectations we have is that technology will help us to work the usual faster, smarter, better. If we don't have waitlists, then we become an attractive place for hospital referrers to send patients. One of the stressful things for lots of patients is waiting to get seen, so if you don't have a wait to get seen then not only is that better patient experience, but also the delivery of care has got to be improved. So that may influence referrers' behaviors".

Towards the future: Investing in HIT to improve clinical research and patient recruitment

The third framing practice they used in the ongoing process of justifying HIT investments was framing HIT as improving their clinical research, and hence as a way of maintaining and

enhancing their international reputation. The HIT and technology director highlighted the importance of data as "the most important asset" after patients and staff:

"The progression towards digital data now means it is possible to record, access and analyze data in much larger amounts. The acquisition, curation, management, analysis and exploration of data drive the medical research industry and is increasingly seen as the most important asset after patients and staff".

Not only did they envision HIT as improving clinical research, but also as improving their ability to recruit patients for scientific trials. A consultant physician at AHP2 explained that sharing patient anonymized data through EMRs could help them "obtain target patient sample sizes for scientific trials". The consultant physician emphasized the importance of recruiting patients for such scientific trials:

"An essential part of our research work is commercial trials and the ability to recruit appropriate patients speedily and rapidly and then follow them up and use the various systems that they require us to do so, is also very important as well… leveraging IT is a brilliant way of doing that".

Overall, this framing strategy helped AHP2 frame HIT as fully supporting the hospital in its research and development vision, by creating a robust environment for research to enable clinical staff to compete in the national and international research market. This framing practice justified HIT investments as a way of providing accessible, automated performance dashboards for performance monitoring; forecasting and modelling of data and the production of real-time reports and dashboards.

Maintaining HIT reputational value

However, although AHP2 envisioned enhancing their reputation through long-term, proactive value seeking framing practices explored above, they did not draw on stable conceptions of value, but rather framed HIT reputational value as mutable, something they had to continuously engage with to secure, not a one-off outcome of HIT investments. This involves justifying actions such as the "maintenance" work of value over time, reputation vulnerability and HIT as threat to reputation, all of which emphasized the mutable nature of value and show the diverse generative opportunities for performing reputational value. AHP2 practitioners were framing HIT as a threat to their reputation, where HIT implementation could disrupt established healthcare practices, highlighting the mutable nature of HIT value. A business change manager at AHP2 commented on this:

"… when an organization has introduced technology based projects they typically are not normally going to work right first time […] there is a whole variety of issues that falls out of that project that

can impact straightaway hospital reputation […] in some of my past activity I have seen some major implementation of IT based projects and really the reputation of the hospital has fallen in most instances almost straightaway on that".

At the heart of these issues, according to the clinical lead of intensive care at AHP2, is the way HIT can come in conflict with the already established healthcare care practices. For example:

"Any IT implementation may crystallize problems […] what you are not taking into account are the unconscious, not recognized, mechanisms that have been put in place by people to support actions, and when you put the technology in place […] any problem becomes the fault of the technology, even if it has nothing to do with it".

Relatedly, another important aspect of justifying HIT investment was reputational value maintenance, where practitioners at AHP2 emphasized that maintaining their international reputation was a continuous process rather than a static one. As a transplant consultant explained:

"Our reputation is enormously important and in order to maintain that reputation we need to keep delivering every single day of every single week or every single month of the year, you cannot rest on your laurels because you will be moving behind".

Finally, AHP2 practitioners recognized that even the most favorable and established reputations, including theirs, cannot be taken for granted. In justifying HIT investments, the service improvement program director noted how reputational value is vulnerable:

"… [reputation represents] both sides of the same coin in my view, so good reputation, bad reputation have different consequences, but you cannot consider one without considering the other, so they're just two sides of the same coin… the time and effort that goes into building and establishing a good reputation and the ease at which that can be flipped […] and then the time and effort that goes into trying to recover it […] for me it's two sides of the same coin".

Through the framing practice of maintaining HIT reputational value, AHP2 practitioners were conceptualizing the contingent status of HIT reputational value as both generative (forming as a prerequisite for further benefits to come, such as enhancing their reputation with different stakeholders), but also as vulnerable (forming as a hindering factor bearing negative consequences for hospitals).

In summary, the framing practice of maintaining HIT reputational value continuously points to the importance of continually engaging in framing practices for HIT value, as a consequence

of ongoing evaluation, where hospitals need to engage in a continued investment of effort to sustain favorable reputational value from their stakeholders. In other words, even though HIT reputational value may appear lasting and enduring at one point in time, it cannot be taken for granted, as it can also be depleted temporally; stakeholders can change their perspective quite significantly, based on the threat HIT poses. Hence, the process of justifying HIT investments may be conceptualized as an ongoing evaluating process that relevant hospital stakeholders are constantly framing HIT value.

A process model of framing practices and reputational value in healthcare

As shown on figures 2 and 3, we identified framing practices that senior managers and other practitioners used to perform justifications of HIT investments, generating potential for multiple facets of HIT reputational value for diverse stakeholders (such as restoring, enhancing, and maintaining reputation). We synthesize our findings across the two cases into a general process model (shown in Figure 4 below), which facilitates cross comparison of the temporally oriented framing practices performed at our case hospitals.

----------Insert Figure 4----------

First, we find that practitioners used temporally orientated framing practices to justify HIT investments for overcoming issues of the past, addressing present issues, and finally, projecting towards the future. Our model highlights that the time horizon (short or long term) and value seeking approach (reactive or proactive) matter for justifying HIT investments. For example, in the case of AHP1, the short-term, reactive temporal orientation of their "crafting urgency" framing practice was key for helping the hospital mobilize after the very critical CQC inspection and in devising a framework for quality improvement using different HIT. At the same time, they were also using framing practices to address present issues. For example, the short-term, reactive temporal orientation of the tactical framing of "displaying professional practices" justified the urgent need for AHP1 to develop their own mobile applications to enable the monthly tracking and evaluation of CQC compliance targets, through real time digital scores. In addition, they justified investing in HIT as providing EMR information that can act as a "weapon for contract negotiation" with commissioner groups and make them seem more "professional than rooting around for the odd note". As we show in final section of AHP1 analysis (see restoring HIT reputational value), they eventually convinced CQC they met the regulatory standards and eventually restored their reputation.

However, despite crafting urgency and addressing present issues, practitioners at AHP1 also used framing practices oriented towards the future. Their framing practice of "improving

relationships with key stakeholders" envisioned reputational value for other stakeholders beyond CQC, such as improving the negotiating position with commissioners, GPs and by potentially attracting hospital staff. This suggests that temporally orientated framing practices can be overlapping with different time horizons and value seeking approaches simultaneously. Even with a major organizational failing and a sense of urgency to act and overcome the past and address present issues, temporally oriented framing practices can also stretch towards the future.

Second, in contrast to AHP1, practitioners at AHP2 were oriented towards the future and mostly used long-term horizons and a proactive value seeking approach. For example, the framing practice of "envisioning national and local strategies" was centered on their vision of delivering a "digital hospital without walls" and was used to justify HIT investments as an opportunity for maintaining, enhancing and reproducing their reputation in the future. Also, their framing practice of "creating strong business partnerships" with commissioners, GPs and other referring hospitals, helped them in justifying HIT investments as providing reputational value for the hospital. This framing practice is similar to AHP1's practice of "improving relationships", where practitioners at both hospitals used a long-term time horizon and a proactive value seeking approach. Similarly, AHP2's framing practice of "improving clinical research and patient recruitment" allowed them to justify HIT investments as providing reputational value from improved outreach to patients, and to clinical stuff from exploiting data for medical purposes. As the model demonstrates, in both cases, practitioners were performing framing practices that appealed to different stakeholders, unpacking multiple facets of reputational value, rather than a singular notion of reputation.

Third, our model emphasizes the mutable nature of value, which we summarize as HIT value dynamics, by showing the diverse generative opportunities for reputational value. For instance, in the case of AHP2, practitioners used the framing practice of "maintaining HIT reputational value", recognizing that HIT can threaten reputation. Taken together, our findings show the process and practices through which practitioners are justifying HIT investments in an ongoing manner. Our model highlights that the framing of value is an ongoing process, and reputational value mutable. Further, we unpack the multiple facets and possibilities for performing HIT reputational value.

DISCUSSION

In this paper, we have addressed the question of how healthcare practitioners enacted framing practices for justifying HIT value, with a focus on reputational value. Through a cross-comparative case study, our study elaborates theory on the role of temporally oriented framing

practices which perform multiple justifications of HIT reputational value, leading to different possibilities by which reputation is restored, enhanced or maintained. Our analysis suggests a re-orientation of value, from being a singular, one-off outcome, to a process understanding of how value (in our case reputational value) may be mutable. We synthesize our empirical findings in a process model of framing practices and reputational value which contributes an understanding of the process of justifying HIT investments for multiple facets of reputational value. This process is dynamic and ongoing. Such a view highlights our understanding of value as being enacted through framing practices which invokes multiple stakeholders. Below, we describe how our findings contribute to the literature on HIT investments. Further, we develop the concept of value mutability as an important elaboration of enacting HIT value, with specific reference to reputational value.

Implications for HIT value literature

Our study suggests a number of implications for the business value of IT (Kohli & Grover, 2008; Melville et al., 2004) and for HIT (Devaraj & Kohli, 2003). Previous work has conceptualized HIT value as either the intrinsic property of IT, or the subjective preferences of the evaluative audiences shaping IT value. On the other hand, scholars argue that pre-existing categories exercise disciplinary effects on organizations, which leaves organizational actors and IT strategists with little room to maneuver (Meyer & Rowan, 1977). As Kornberger (2017, p.1766) argues, we encounter a not unusual impasse: an essentialist approach to technology which clashes with an "over-structuralized, sociological account of the conditions of the (im-) possibility of agency". First, our performative framing perspective contributes an alternative view bringing into focus agency, while keeping an eye on structural constraints. This is a "bottom-up" approach that shows practitioners can and do enact new value understandings through temporally oriented framing practices, rather than acting on already imposed categorizations by intermediaries that are frame-making. Related to our "bottom-up" view, we also contribute by showing the mutability of IT value, that is, HIT reputational value as a dynamic, ongoing process, continually unfolding and constituted by ongoing reconfiguration. Previous work has emphasized IT value in terms of new organizational processes that produce specific, relatively stable value outcomes, such as financial (Menachemi, Burkhardt, Shewchuk, Burke, & Brooks, 2006) or operational value (DesRoches et al., 2008). These value outcomes are usually examined in isolation (see Schryen, 2013 for a recent review). Our study challenges this assumption by viewing the justifying of HIT investments and performing of value as an ongoing accomplishment, defined by maintenance work and the possibility of having to either restore, maintain or enhance reputation.

Second, our findings have implications for the recent stream of research that examines value as articulated in multiple dimensions (Barrett et al., 2016; Tempini 2017). Our process model connects with previous findings on the creation and making of value in practice, contingent value dynamics (Tempini, 2017) and valuation processes as shaped by encompassing regimes of worth that create multiple kinds of value (Barrett et al., 2016). However, it differs in providing insights into the performative mechanisms through which justifications of value are performed and "brought into being", as well as by unpacking multiple facets of the same reputational value. We confirm Tempini's (2017) nonlinear, contingent value dynamics that warn against eventual interpretations of value creation as a linear accretion trajectory, but at the same time, extend these findings by showing the process and mechanisms through which these dynamics are performed. For instance, our performative framing model shows that temporal orientation is an important aspect of the IT investment justifying process, which influences framing practices in the enactment of HIT value. As such, we show how these contingent value dynamics may play out, and the mutable, tenuous forms of HIT value that can lead to both favorable (restoring, enhancing) and unfavorable (threatening reputation) value at different points in time.

Moreover, we build on Barrett et al., (2016) who examine how the use of the platform and stakeholder participation led to different values being enacted, such as reputational, financial, service, and epistemic. We extend this line of research by problematizing further the nature of the phenomenon of value, by showing the mechanisms through which reputational value can be enacted in different ways. Framing practices may lead to favorable reputational value being enacted for commissioners, regulators and hospital staff, yet negative assessment of new clinical practices, such as from unplanned disruptions during IT implementation, can enact negative reputational value from the perspective of patients. This insight, coupled with our findings of the ongoing need for maintaining reputational value, suggest organizations need to engage in continuous efforts for enacting aspects of the same value differently for different stakeholders. At the same time however, our findings emphasize that such value is neither certain, nor a final outcome, but rather implicated in a continuous process of justifying and framing HIT.

Third, and relatedly, we contribute by responding to the call made by Salge et al., (2015) for exploring how HIT can enhance organizational reputation among other social goals. Although previous research illustrates that organizations following IT fashions tend to have better reputation regardless of performance improvement (Wang, 2010), it falls short of demonstrating the process through which this happens. By adopting a "bottom-up" view of

how practitioners enacted framing practices at the initial resource allocation stage, our model conceptualizes HIT reputational value benefits for different stakeholders, addressing the missing interrelations of value between healthcare stakeholders. At the same time, we suggest that framing value is distributed across different intermediary stakeholders. This relates to the valuation literature (cf. Kornberger, 2017), which argues that valuation practices involved a series of different intermediary actors, such as critics, credit scoring agencies or investment bankers, who shape preferences and act as guideposts for others' deliberations and decisions. In other words, these are "frame-makers" (Beunza & Garud, 2007) that define conventions and structure the understanding of value. In our cases, the healthcare practitioners were invoking multiple other stakeholders, such as commissioners, GPs, patients and regulators in their framing practices for reputational value through HIT. As such, our model points to the distributed agency of value (Kornberger, 2017).

Implications for practice

Our study also has practical implications. First, we emphasize the importance of temporally orientated framing practices in understanding the process of justifying HIT investments and performing reputational value. Practitioners can be mindful of how short/long term time horizons and the reactive/proactive value seeking approaches they use can influence their justifying of HIT investments and eventually enact different value possibilities. In addition, as our cross-case comparison suggests, temporally orientated framing practices can be overlapping with different time horizons and value seeking approaches simultaneously. Even though our two hospital cases were facing contrasting pressures, practitioners used both a reactive and proactive value seeking approach where necessary. For instance, a short-term/reactive temporal orientation might be useful for hospital staff to take actions that produce tangible results and overcome HIT disruptions to practices, whereas using only long-term/proactive framing practices might be too visionary so that hospital staff may get discouraged or lost in the day-to-day struggles with HIT (in relation to HIT risks). At the same time, our insights around value mutability suggest practitioners can transition from one set of temporally oriented practices to another, as external situations change.

Second, the multiple stakeholders our case organizations invoked in their framing practices suggest that hospital managers and IT professionals should focus not only on stakeholders they believe to be the most strategic, such as regulators or funding commissioners, but also to a wider range of stakeholders, including patients, GPs and their own hospital staff. Beyond healthcare, managers need to be mindful of reputation multiplicity (Boutinot et al., 2015; Carter & Deephouse, 1999; Mishina, Block, & Mannor, 2012), that is, having reputation in various

domains. For example, having a favorable reputation with regulators might not necessarily ensure a favorable reputation with clinical staff or commissioners. Therefore, practitioners might be framing HIT investments broadly, to incorporate different stakeholders. We suggest that managers might strategically appeal to a plurality of stakeholders (e.g. clinical staff, regulators, commissioners, GPs, other referring hospitals).

Third, our insights around value mutability and the ongoing process of justifying HIT investments can help practitioners better understand the dynamic nature of mutable reputational value. Our findings suggest that even though it is widely recognized that reputation takes significant time and effort to develop (Fombrun, 1996), forming based on past actions (Balmer, 2003; Barney, 1991) and becoming an enduring and "sticky" resource (Ang & Wight, 2009; Fombrun & Van Riel, 2004; Schultz et al., 2001), reputational value is neither certain, nor a one-off outcome, as illustrated by our process model.

CONCLUSION

In this paper, we studied how practitioners justified HIT investment at two UK hospitals, with a focus on reputational value. We have developed a process model of framing practices and reputational value, which provides an understanding of the dynamic way in which reputational value is performed through the ongoing process of justifying HIT investments, which is influenced by the temporal orientation of individuals' framing practices. Further, our study provides an enhanced appreciation of value mutability; value as not a finalized outcome, but rather, mutable in its enactment through framing practices that are temporally oriented.

The limitations of this study offer opportunities for future research in this area. Although focusing on reputational value allowed us to elaborate theory and provide a more granular understanding of the dynamics and mechanisms in the process of justifying HIT investments, future research can extend our findings to other dimensions of value reported in the literature, such as epistemic, platform, scientific and service values. For example, are aspects of the aforementioned values enacted in the same way as reputational value? Are they as mutable as reputational value? These questions can help shed more light on the phenomenon of HIT value.

Relatedly, although our study examined the orientation of framing practices towards time, future studies can study the performativity of value over time, in relation to value fragility. As argued by other scholars, performativity is never a settled state of affairs, but must instead be considered as an ongoing journey (Garud, Gehman and Tharchen, 2017). Even if a constitutive order of value is reached, it is "fragile" (Callon, 2010), as the unravelling of felicitous

conditions underlying such constitution will de-constitute the original order. Our findings on the framing practice of "maintaining HIT reputational value" allow us to speculate on the fragility and tenuous nature of reputational value. For example, even though HIT reputational value may appear lasting and enduring at one point in time, it cannot be taken for granted, as it can also be depleted temporally; stakeholders can change their perspective quite significantly, based on the threats HIT poses. Therefore, while we did not observe value fragility in our cases, we anticipate this is a possible and important topic that future studies can build on and shed light on the process through which reputational value, and other types of value identified in the literature, are performed on an ongoing basis.

Second, scholars can pay more attention to the multiple ways different materialities, other than HIT, may perform value differently, by enabling and constraining framing practices. This is an important area for future work given the increasingly established view that material artifacts and materiality more broadly are fundamental components of practices (Bechky, 2003; Carlile, 2002; Feldman & Orlikowski, 2011; Leonardi & Barley, 2008), or constitutive of phenomena (Orlikowski & Scott, 2008). Relatedly, future studies can pay attention to distributed agency of valuation practices by paying closer attention to non-human actor agency in defining value (Kornberger, 2017). Experts, critics, but also non-human agents, such as algorithms, are involved in practices of valuation. Analytically, this focus on distributed agency suggests understanding valuation practices not as static information on, and assessment of objects, but as a dynamic, ongoing process flowing through networks of people, intermediaries, and non-human actors.

Third, our findings are limited to the extent that we focused on the hospital organizations' perspective and framing practices. Future research can further enrichen data collection at the field level, enabling a more holistic understanding of the ongoing process of justifying HIT investments for different stakeholders. For example, research could more closely observe and conduct interviews with evaluating stakeholders, such as inspection teams of regulators, healthcare commissioners, media journalists, patient advocate group leaders, patients, and GPs. Nevertheless, despite these limitations, we believe our theoretical insights on reputational value and mutability can be analytically generalizable to other relevant contexts beyond health care.

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FIGURE 1
CATEGORIZING TEMPORAL FRAMING PRACTICES ACROSS CASE STUDIES

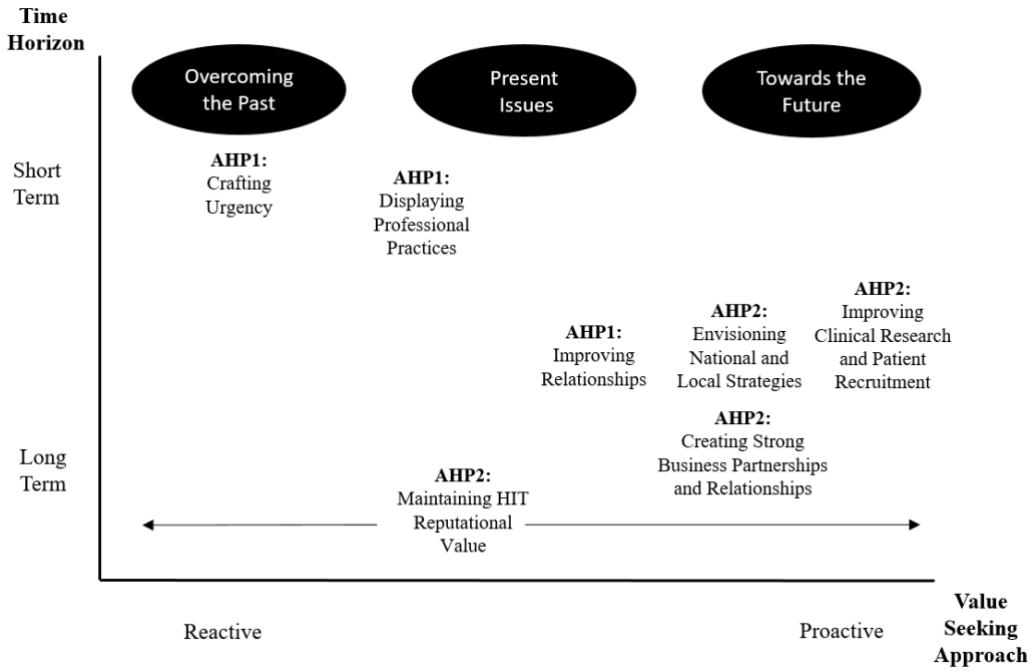


FIGURE 2
SUMMARY OF FINDINGS AT AHP1

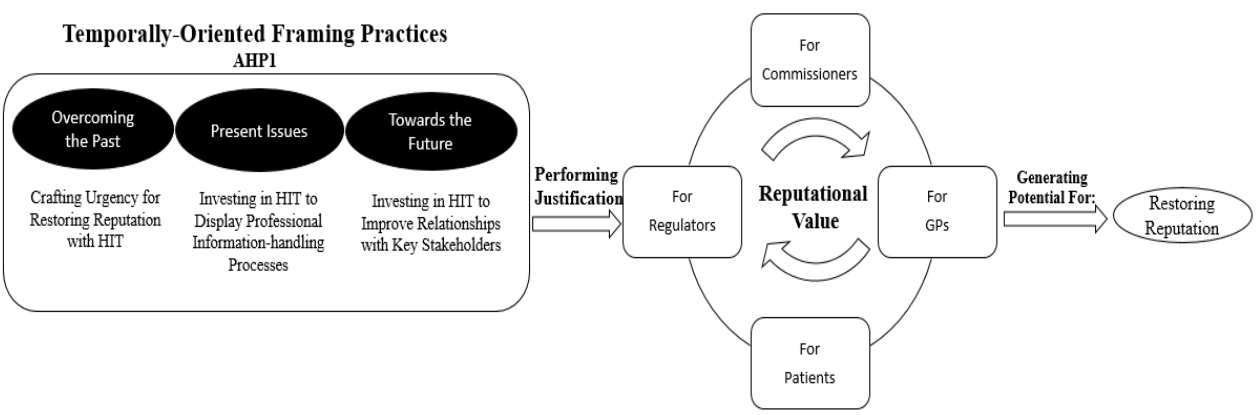


TABLE 1
TEMPORALLY ORIENTED FRAMING PRACTICES FOR RESTORING REPUTATIONAL VALUE AT AHP1

Aggregate Dimension	Temporal Orientation	Framing Practices	Justifying Actions	Exemplary Quotes
Overcoming the Past (Practices anchored in solving past problems)	**Short-term horizon** **Reactive Value seeking approach**	**Crafting urgency for restoring reputation with HIT**	Investing in HIT urgently to collect, store and visualize data to CQC in an accessible manner	*"The framework focuses around a self-assessment approach undertaken by clinical team through HIT. This assessment measures local compliance against a wide range of standards derived from the CQC" (AHP1 Annual Strategy Document)* *"We will develop an internal quality assurance framework that underpins improvements in quality, safety and effectiveness at the point of care delivery through HIT" (AHP1 Annual Strategy Document)*
			Investing in HIT will help us devise a framework of action	*"CQC quite rightly picked us up on it and so we said right okay we'll put in an improvement plan through HIT and then we will monitor it" (Chief Pharmacist)*
Present Issues (Tactical practices anchored in short-term horizons)	**Short-term horizon** **Reactive Value seeking approach**	**Investing in HIT to display professional information handling processes**	Using EMR makes us seem more professional than rooting around for the odd note with our stakeholders	*"If regulators know your record keeping systems are robust… then they will have more confidence in what you are doing" (Consultant Physician)* *"I think at a sort of very basic level, if an organization can't in 24 hours produce reasonable information in response to a public Freedom of Information request, a local health organization ringing up and asking to know stuff and regulators, they are not very good. We have had immense difficulties with our purchases of one sort or another when we can't provide them with information they believe we ought to be collecting and having electronic form" (Medical Director)*
			Using apps to collect information helps us convince CQC of our	*"CQC need assurance that we are being mindful of any aspect of assessment that may impact upon the patients' outcome" (Nurse Matron)*

			compliance with standards	
			Using EMR information as weapon for contract negotiation with Commissioning Groups by monitoring safety of services	*"We have a block contract which means that we don't automatically get paid if we see more people… so we have to negotiate [funding] at the end of each year [with commissioners]. So being clear about what that increase is and which teams have experienced what increase and what the impact of that was, so other bits of information like the acuity of the patients who are being cared for, that's all vital to the case we make. As well as understanding what's going on in the service" (CEO)* *"Technology helps us with commissioners because we have more granular information about all of our interventions, how much they cost and how long they take, so… the data that we can extract from our technical solutions become a selling mechanism in themselves"(Chief Operating Officer)*
Toward the Future (Strategic practices anchored in long-term horizons)	**Long-term horizon** **Proactive Value Seeking Approach**	**Investing in HIT to improve relationships with key stakeholders**	HIT can improve stakeholder relationships by providing detailed information	*"Good IT systems have substantial benefits to the stakeholder relations… an organization that has immediate access to its data is one that's impressive to work with" (Clinical Psychologist)*
			HIT can help us by attracting and retaining hospital staff	*"HIT allows you to attract staff more easily at all levels… it is easier to recruit people" (Consultant Anesthetist)*

FIGURE 3
SUMMARY OF FINDINGS AT AHP2

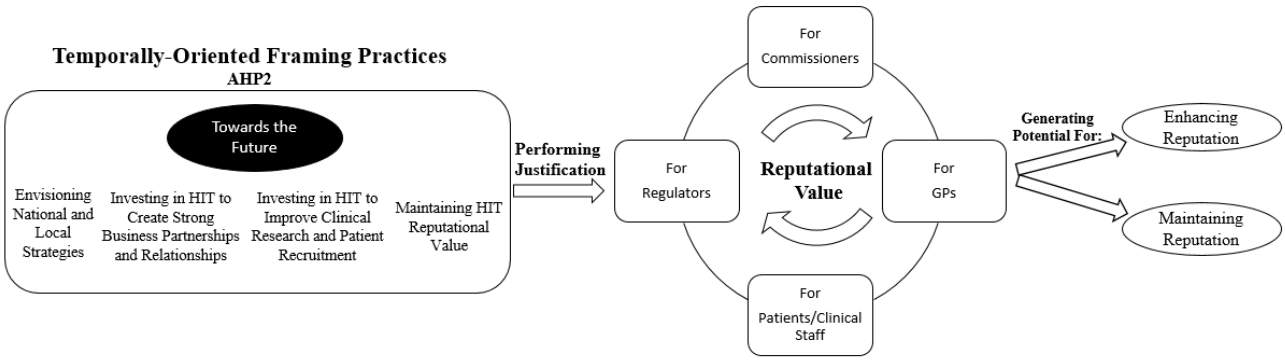


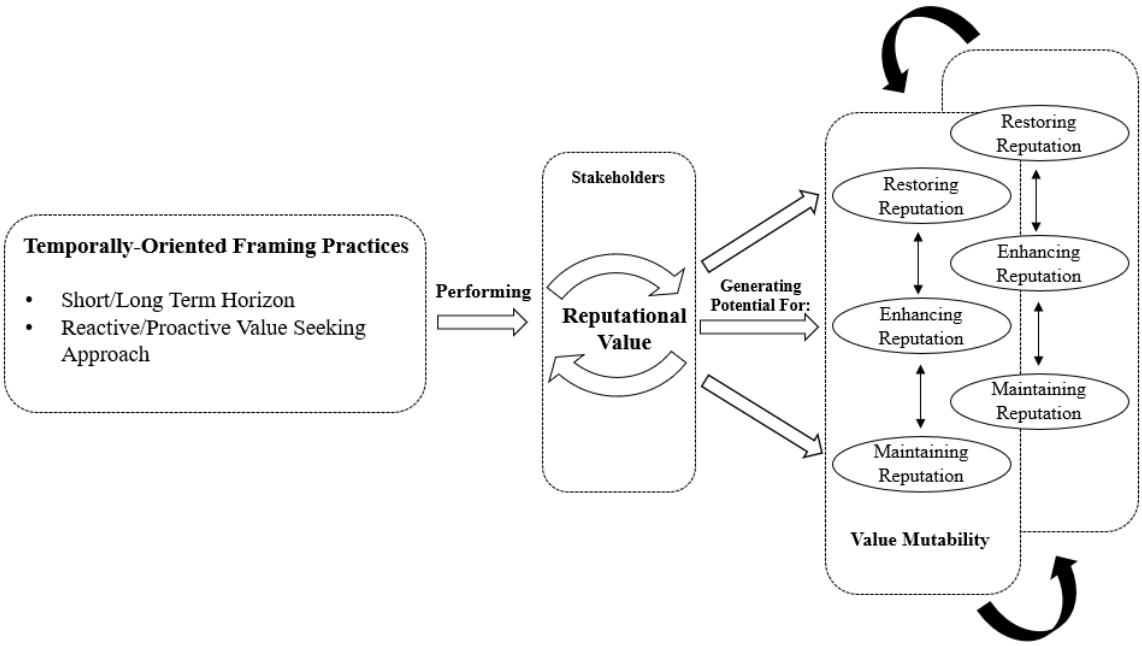
TABLE 2
TEMPORALLY ORIENTED FRAMING PRACTICES FOR ENHANCING REPUTATIONAL VALUE AT AHP2

Aggregate Dimension	Temporal Orientation	Framing Practices	Justifying Actions	Exemplary Quotes
Toward the Future (Strategic practices anchored in long-term horizons)	**Long-term horizon** **Proactive Value Seeking Approach**	**Envisioning national and local strategies**	Reimagining the future by responding to national strategic context	*"HIT needs to support the hospital in responding to national strategic initiatives, through delivering systems and infrastructure that directly support the delivery of high-quality care at every stage of the patient journey regardless of location (HIT strategy document)*
			Reimagining the future by responding to local strategic context	*"HIT needs to support the hospital in responding to local strategic initiatives through enabling us to maintain and build further worldwide recognition for our care, training and research" (HIT Strategy Document)*
			HIT can support and future proof our hospital	*"From a HIT perspective, the challenge is one of creating a strategic HIT service that can support and future proof the hospital whilst bringing business-as-usual practices into an age of rapidly advancing technological change" (HIT Strategy Document)*

Toward the Future (Strategic practices anchored in long-term horizons)	**Long-term horizon** **Proactive Value Seeking Approach**	**Investing in HIT to create strong business partnerships and relationships**	Investing in HIT to create strong business partnerships and relationships ● With commissioners ● With other referring hospital	*It is recommended that the hospital invest in HIT to create a strong business partnership that will enable us to meet and exceed both local and national expectations and implement a truly digital hospital" (HIT Strategy Document).* *"By using HIT we can negotiate with commissioners in terms of the levels of activity that we do" (Medical Director)* *"We can use HIT as an influencer with referrers. So by way of example, if we can manage our waiting lists more efficiently, more effectively using E-Hospital, if I'm a referring district general hospital I may look around and say, so who can do that radiology test for me, I may choose to send my patient to our hospital because we don't have a waiting list, because its managing its patient flows so much better with the use of technology as well" (HIT & Technology Director)*
Toward the Future (Strategic practices anchored in long-term horizons)	**Long-term horizon** **Proactive Value Seeking Approach**	**Investing in HIT can help us improve clinical research and patient recruitment**	Investing in HIT to improve clinical research	*"I think the use of an EMR facilitates recruitment to clinical trials that will be hugely important… being able to ask a database who's got this condition, who's got this bug and who's not is hugely important for reputation… which would mean a lot of money for the hospital" (Consultant Physician)*
			Investing in HIT to improve ability to recruit patients for scientific trials	*"An essential part of our research work is commercial trials and the ability to recruit appropriate patients speedily and rapidly and then follow them up and use the various systems that they require us to do so, is also very important as well… leveraging IT is a brilliant way of doing that" (Medical Director).*

Toward the Future (Strategic practices anchored in long-term horizons)	**Long-term horizon** **Reactive Value Seeking Approach**	**Maintaining HIT reputational value**	Threat-to-reputation: HIT can disrupt care pathways when implemented	*"The problem with HIT is that they will, depending on implementation, affect some of your pathways, and you try to decrease that, [but] it will still disrupt some of the pathways. So, you need to be careful for that […] in fact, it can disrupt pathways so much that […] there can be an increase in death" (Medical Director)*
			Maintaining reputation on an ongoing basis	*"We need to maintain our reputation in research circles as well, an important part of our research work, well an essential part of our research work really is commercial trials and the ability to recruit appropriate patients to them speedily and rapidly and then follow them up and use the various systems that they require us to do so" (Nurse Lead – eHospital Coordinator)*
			Our reputation is vulnerable	*"We have a lot of transplant patients around the country because we are a centre… so we are using more technology [like skype] for their follow up assessments… they don't want to travel all the way here… but we have to be careful because sometimes you can miss things on video calls with patients that you would catch when seeing them [face to face]… we have to get it right and make sure the patient gets the best care… otherwise [it can damage] our reputation and harm the patient" (Senior Transplant Nurse Lead)*

FIGURE 4
A PROCESS MODEL OF FRAMING PRACTICES AND REPUTATIONAL VALUE IN JUSTIFYING HEALTH IT INVESTMENTS



Paper Two

Searching for Place to Grow Digital: Where and How to Scale Up 3D Printing in Hospitals?

ABSTRACT

This paper examines how digital innovations require situated places for scaling up across hospital organizations. Through a five year long ethnographic fieldwork study, which focuses on the case of 3D printing at a clinical innovation department of a major UK National Health Service (NHS) hospital, we extend theory on how places are implicated in the digital scaling of innovations. Informed by a practice lens and a process research approach, we contribute a theoretical model that goes beyond the view of place as a geographical locale and theorizes the constitutive role of resourcing strategies, materiality and location meaning, which taken together, explain *how* and *why* the digital innovation of 3D printing failed to scale up on three different occasions. Moreover, we unpack place dynamics for scaling 3D printing, involving processes of place bending, framing and jumping. We conclude by discussing implications for the literatures of digital innovation and scaling.

Keywords:
places, digital innovation, 3D printing, practice theory, materiality, resourcing

In today's digital age, information technology (IT) is pervasive and shaping distributed innovation through processes of digital invention, development and implementation that provide novel value to multiple stakeholders (Nambisan et al. 2017, Yoo et al. 2012). A key focus of the digital innovation literature has been on the generativity and convergence of digital technologies (Yoo et al. 2012, Zittrain 2006) in enabling widespread transformation. These digital affordances allow for the possibility of converging disparate user experiences and incorporating new digital capabilities after the initial design phase (Huang et al. 2017, Kallinikos et al. 2013). Overall, the literature highlights that generativity and digital affordances can enable digital innovations to grow and scale rapidly in unprecedented ways (Henfridsson and Bygstad 2013, Huang et al. 2017, Yoo et al. 2010).

However, the literature is silent on the early but critical stages of starting digital initiatives. In this paper we examine how digital innovations require situated places for scaling up across the organization. Where are they implemented and how do they take root in specific places across the organization to scale? These questions highlight the continued importance of place and may sound counter-intuitive, as one might expect place to lose its significance with the digitization of innovation. However, we observed the opposite. Our fieldwork study, which focused on the case of digital innovation, 3D printing (3DP), at a clinical innovation department of a major UK National Health Service (NHS) hospital, uncovered findings which were both surprising and somewhat unexpected.

The clinical innovation department is a multidisciplinary center that supports and accelerates the development of innovative medical technologies with the aim of addressing unmet patient needs, while improving patient safety. 3DP requires organizing across diverse occupational communities of practice within the hospital, hence CIG has comprised of heterogeneous experts at different points in time throughout our fieldwork. Over a period of five years, innovation actors attempted to scale 3DP in three distinct places. However, their attempts failed to cultivate and establish the development of the digital innovation in the hospital. The role of geographically distant locales and places in shaping innovation resonates with recent research that has emphasized the important role of place in organizational work (Lawrence and Dover 2015, de Vaujany and Vaast 2013). In this paper, we therefore examine *how places matter in digital innovation, and with what implications for subsequent scaling.* The paper builds on the wider social science scholarship that has highlighted how the physical and social spaces

influence interaction in multiple and often unexpected ways (Lefebvre 1991, Massey 2005, Oborn et al., 2019).

To do so, we extend theory (Locke 2001) on how places are implicated in the digital scaling of innovations and theorize why places matter in scaling up. We followed an inductive research design, starting from an interest in organizing 3DP practices across occupational boundaries of a hospital, and remained open to emerging fieldwork insights. Informed by a practice lens (Feldman and Orlikowski 2011, Nicolini 2012) and a process research approach (Langley 1999), we collected detailed longitudinal data over a period of five years on how different occupational groups actively shaped and reshaped places to implement 3DP, by deploying ethnographic methods and by following key episodes processualy (Garud et al. 2017, Langley 2009).

We contribute to the literature in two ways. First, we contribute a theoretical model that goes beyond the view of place as a geographical locale and theorizes the constitutive role of resourcing strategies, materiality and location meaning, which taken together, explain *how* and *why* the digital innovation of 3DP failed to scale up on three different occasions. Resourcing strategies refers to the ways in which occupational groups use resources, and how use, in turn, may shape subsequent 3DP development. By location meaning, we follow insights about the symbolic and sociopolitical nature of places to show how occupational groups use their own definitions, meanings, value and rules onto a place. We show how and why places remain important despite the digitization of innovation. Second, we contribute to the scaling literature by showing how scaling is an emerging, deeply contextualized process in space and time. More specifically, we unpack place dynamics for scaling 3DP, involving processes of place bending, framing and jumping. We highlight the challenges associated with scaling digital innovations, complementing the literature that argues that generativity and convergence can enable digital innovations to grow and scale rapidly in unprecedented ways (Huang et al. 2017; Henfridsson and Bygstad 2013; Yoo et al. 2010).

RELEVANT LITERATURE

Innovation is recognized as a complex, multi-faceted process (Chesbrough 2003, Van De Ven et al. 1999) that includes multiple organizations, actors and distributed capabilities (Garud et

al. 2013, Nambisan et al. 2017). The literature most relevant for our paper encompasses those studies that examine the scaling up of digital innovations and the role of place in innovation. We argue that where and how scaling up is situated matters for the subsequent growth of digital innovations.

Digital Innovation and Scaling

The literature on digital innovation has highlighted the generativity and convergence of digital technologies (Yoo et al. 2012, Zittrain 2006) in enabling widespread transformation and scaling up. Within this literature, a considerable body of literature has examined how digital technology affordances can enable digital innovations to grow and scale rapidly in unprecedented ways (Henfridsson and Bygstad 2013, Huang et al. 2017, Yoo et al. 2010). Recent work by Huang et al., (2017), for example, focused on how digital ventures scale their business rapidly by drawing on and adding to digital infrastructure. Specifically, the authors identify three mechanisms, data-driven operation, instant release, and swift transformation that underpin the generative process of rapid scaling of the user base of a Chinese venture. Importantly, a key element of scaling up digital ventures, especially at the initial development process, is innovation resources. Scaling up, then, requires the prioritizing, consolidating and channeling of resources towards fueling and materializing the launch of innovations (Huang et al., 2017; Nambisan et al., 2016).

Although there is agreement about the importance of scaling digital innovations and significant work on the mechanisms by which scaling is achieved, research is less clear about *where and how* scaling happens in organizations. This is an important omission, as scaling up happens in situated places and with specific resourcing practices, that can influence the way in which digital innovations subsequently grow. Scholars have long argued about the ability of IT to lift social relations out of local contexts and to stretch them across indefinite spans of time and space (Barrett & Walsham, 1999; Giddens, 1990). However, their work has highlighted the continued importance of place in a digital world. For example, in their study of the development and attempted implementation of electronic trading applications in the London insurance market, Barrett and Walsham (1999) demonstrate that even though IT can facilitate the separation of time and space linked through place, the scaling up of electronic trading around insurance placement across the London Market was resisted and finally not adopted. Specifically, brokers and underwriters feared that IT as a disembedding mechanism, that is, the "stretching" of social relations which allows for the separation of interaction from the

particularities of locales (Giddens 1990), would result in future relations becoming impersonal and at a distance. This was viewed as disadvantageous for developing trustworthiness, since face-to-face interactions were deemed critical to brokers and underwriters in the facilitation of effective negotiations in the best interests of their clients and for reinforcing their global reputation as an innovative marketplace. More recently, Bailey et al. (2012) caution against the lure of the virtual and argue that increased dependence on digital tools to simulate, visualize and test new complex products leads to unintended consequences of separating physical objects and people from the virtual representations of design objects. Taken together, these studies highlight the continued importance of place in a digital world, which is largely absent from the literature on scaling up digital innovations. We examine the relevant place literature next.

Place and Innovation

The role of geographically distant locales and places in shaping innovation processes resonates with recent research that has emphasized the important role of place in organizational work (Lawrence and Dover 2015, de Vaujany and Vaast 2013). It is important to note that space and place, although interwoven, are conceptually different. “Organizational spaces” signify the “various locations that organization and management can be analyzed through” (Taylor & Spicer, 2007). Although space is related to place, as a construct, place captures not only the ability to locate things on a map, but the attribution of meaning to a built form; places are made as people ascribe qualities to them through their sociomaterial practices (Gieryn, 2000). Thus, place is not merely a setting or a backdrop, but an agentic player (ibid).

First, by exploring place as an active ingredient in organizational life through adopting an institutional perspective, Lawrence and Dover (2015) devise an integrated process model showing how places, through containing, mediating and complicating roles, affect how organizational actors understand problems, marshal resources, employ routines and construct connections between concepts. They contribute by broadening the understanding of location in organization studies and document the ontological flexibility of places (as they become social enclosures, signifiers or practical objects) - places represent a nexus of the ideational, social and practical that can "become" distinctly different things in the world through actors' actions. Second, de Vaujany and Vaast (2013) longitudinally show how spatial practices of appropriation, reapprpopriation and disappropriation enact different spatial legacies, imbricating legitimacy claims and space over time. In other words, places can provide “legacies” that act as enduring repositories of an organization’s spatial history. Third, Oborn

et al., (2019) investigate the innovation processes that produced a mobile money payment service and conclude that the local practices, materialities and values associated with distinct geographical places necessarily shape and possibly transform the innovation over time. Finally, Rodner et al. (2019) devise a theoretical model that explains how the dimensions of space – the material, social and symbolic – interact, enable and reinforce each other in understanding disruptive and defensive institutional work. These studies emphasize how places can have profound consequences for the actors involved, their practices and the outcomes of innovation processes.

This is especially the case in the healthcare context. We know, for example, that technological innovations can serve as occasions for structuring (Barley 1986). In his seminal study, Barley shows that where technologies are placed can lead to different outcomes. Although two identical CT scanners occasioned similar structuring processes in two radiology departments, at different hospitals – Urban and Suburban, they led to divergent forms of organization. While the study provides important seminal contributions on technology and structure, the role of place is not explicitly theorized. Instead, Barley studies the implementation of CT scanners at the same place - the radiology department, within two different hospitals. This suggests that there are outstanding questions regarding context and the role of place. For example, what if we examined the development of the same digital innovation in different places within the same organization? How would taking seriously the notion of situated places be implicated in the scaling of digital innovations?

The literature has recognized the importance of such considerations, albeit implicitly. For instance, Barrett et al., (2012) studied the introduction of a new digital innovation of a dispensing robot in a pharmacy context and demonstrated how the physical arrangement of the dispensary changed, introducing unintended consequences such as influencing the work practices, interests and relations of three interdependent occupational groups. However, by focusing on the robot's hybrid materialities and shifting boundary relations, the authors do not explicitly theorize the role of place in the process of scaling up the digital innovation. In this paper, we therefore focus our efforts in examining *how places matter for digital innovation, and with what implications for scaling?* To address our research question, we examine the resourcing literature next and devise a theoretical framework that takes resourcing, materiality and location meaning seriously in examining the scaling up of digital innovations.

Resourcing for Digital Innovation

Resources have long been recognized as important in innovations involving processes of digitization (Henfridsson et al. 2018, Lyytinen et al. 2016). More broadly, IT plays a central role in the formation and functioning of digital service ecosystems, as resources (importantly, information, skills, financing and knowing) are combined and exchanged in new ways that create value for actors in the process (Barrett et al. 2015), which may lead to multiple, open ended value paths (Henfridsson et al. 2018). The process of digitization brings novel heterogeneous resources together, blurs industry boundaries and enables new ecologies (Lyytinen et al. 2016).

In contrast to viewing resources as stable entities, practice-based theories (Feldman and Orlikowski 2011, Golsorkhi et al. 2015, Johnson et al. 2007) are particularly attentive to how resources are used, and how use, in turn, may shape subsequent innovation developments. Resources, in this way, are viewed as the "specific physical, human and organizational assets that can be used to implement value-creating strategies" (Eisenhardt and Martin 2000, p. 1007). Specifically, the "resourcing" perspective (Feldman 2004, Feldman and Worline 2016, Howard-Grenville 2007, Sonenshein 2014, Wiedner et al. 2017) builds on the practice turn in the social sciences to reconceptualize resources from stable entities to understanding processes of resourcing. It is how people use "potential" resources that become "actual" resources through their use (Feldman 2004, Sonenshein 2014) and influence innovation. In the context of digital innovation, it is important to examine resourcing practices, as this perspective shows how resources transform in unexpected ways as a result of change in organizational routines and how this transformation of resources makes resistance to change difficult to predict. This is indeed the case with digital innovation, which can provide multiple, open ended value paths (Henfridsson et al. 2018) that are uncertain, especially at the development stage. The resourcing perspective can complement the theoretical understanding of scaling up digital innovations, by helping us unpack how and when the resourcing practices of the groups involved are actively shaping places which are consequential for the success or failure of scaling. For instance, for the innovation of 3DP to be implemented, the occupational groups in our study negotiated, justified and resourced new spatial arrangements such as the introduction of innovation labs, as well as requiring the reconfiguring of the spatiality surrounding existing places to turn the innovation into an organizational reality. Second, we suggest that a resourcing perspective can help shed light on identifying and justifying places when organizing digital innovation.

Theoretical Framework

Our practice perspective views an ecology of places as interconnected and relational (Nicolini 2011, Østerlund and Carlile 2005), enacted by disciplinary (Lynch 1991) and resourcing practices (Feldman 2004, Howard-Grenville 2007) and recognizes the constitutive role of materiality and location meaning. Following practice theorists (Feldman and Orlikowski 2011, Schatzki 2002, 2005), this view suggests that phenomena are situated and have a specific 'location', situated in a field of organized interests and in relation to other events, places and phenomena (Nicolini 2011). Our theoretical framework suggests places are relationally interconnected and actively involved in the scaling of digital innovations. More specifically, for our purposes, we take seriously the idea that 3DP innovations bridge the digital and physical domains, as it requires both digital modelling practices and physical 3D printers located in particular places to transform digital models into customized, tangible artifacts. Previous work has recognized the importance of digital and physical materiality in the process of organizing more generally (Faulkner and Runde 2009, Leonardi 2010), and digital innovation more specifically (Barrett et al. 2012). Leonardi (2010) argues that although the materiality of digitally based technological artifacts is harder to see and define than for artifacts in the physical realm, they are no less important. Barrett et al., (2012), building on the characteristics of digitalized artifacts proposed by Yoo et al. (2010), such as programmability, senseability and memorability, show how the robotic digital innovation was implemented and with what occupational consequences for boundary relations. Our practice-based approach highlights the consequential dynamics of materiality in organizations (Orlikowski 2007, 2010), views materiality as how work is instantiated in practice (Beane and Orlikowski 2015) and takes seriously the relationality of places for performing the scaling up of digital innovations.

Finally, we follow insights about the symbolic and socio-political nature of spaces, which are intimately connected to issues of power (Lefebvre 1991). Connected to our resourcing perspective, spatial manipulation can impact how material and symbolic resources are circumscribed and acquired to influence scaling of digital innovations. Dale and Burrell (2008) conceptualize this use of space by inhabitants as enactment. Therefore, specific locations as enacted and understood by different occupational groups are used to impose a group's own definition, meanings, values and rules onto a situation, in our case, scaling the digital innovation of 3DP.

RESEARCH SETTING AND METHODS

Overall, to address our research question, our aim is to extend and refine theory (Locke 2001) on how places are implicated in the digital scaling of innovations, as well as theorize why places matter in scaling up. We performed a fieldwork study at a clinical innovation group of a UK, NHS hospital (henceforth CIG), spanning a period of five years. The health care sector is an important one to examine the scaling up of digital innovations, as hospitals are revisiting their organizing practices for leveraging the potential of 3DP, with considerable implications for reconfiguring care practices, jurisdictions, relations and identities (Barley 1986, Barrett et al. 2012, Barrett and Walsham 1999). This is especially the case in healthcare, which is characterized by strong social boundaries between health care workers from different professions (Ferlie et al. 2005), created in part by strong professional and occupational identities (Abbott 1988).

Research Setting

We selected this research setting for purposes of explorative richness, as little theoretical precedent exists for inquiry in this domain (Pettigrew 1990). CIG is a multidisciplinary center that supports and accelerates the development of innovative medical technologies with the aim of addressing unmet patient needs, while improving patient safety. 3DP requires organizing across diverse occupational communities of practice within the hospital, hence CIG has comprised of heterogeneous experts at different points in time throughout our fieldwork. Figure 1 visualizes the main actors involved in 3DP, such as biomedical engineering (comprised of mechanical engineers and R&D), as well as professionals, including consultants, technicians, radiologists and surgeons, who work collaboratively to design, develop and implement innovations using 3DP, at a centralized services lab (3DPLab).

---------- Insert Figure 1 here ----------

3DP, otherwise called additive manufacturing (AM), is an illustrative example of digital innovation. It is an emerging technology that transforms digital models into physical objects, by ‘materializing’ information, layer-by-layer. There are several AM processes, differentiated by the manner in which they create each layer (Campbell et al. 2011). For example, the main AM techniques are selective laser sintering (SLS) – using a laser to selectively melt metal or

polymeric power, stereolithography (SLA) – using an ultraviolet laser to harden a photosensitive polymer and finally 3DP – jetting a binder into a polymeric powder. 3DP builds physical objects in contrast to the predominant 'subtractive' manufacturing technique, which involves cutting blocks of material into the right shape and assembling them into more complex products (Campbell et al., 2011). We examine the scaling up of 3DP in a sector that has not been examined before, the medical sector.

3DP has numerous applications and has gained much interest in the medical world. Applications vary from anatomical models mainly intended for surgical planning to surgical guides and implants (Tack et al. 2016). For instance, doctors previously mostly worked with two-dimensional X-ray images, computed tomography (CT) images or magnetic resonance (MR) scans to gain insight into pathologies. With 3DP, they utilize a multitude of 3D renderings of CT and MR images to reconstruct and design a 3D model through computer-aided design (CAD) software, that they can then 3D print with a variety of materials and tactile qualities. The need for improved visualization and surgical outcomes has given rise to 3D-printed anatomical models, patient-specific guides, and 3D-printed prosthetics. The technology is expected to bring about a new era of medical innovation, with claimed benefits such as the quick customization of drugs for unmet patient needs, recent advancements such as tissue and organ fabrication, as well as the creation of customized prosthetics (Ventola 2014).

For our purposes, Jones and Rose (2016) distinguish between two distinct types of digital innovation: those that bridge the digital and physical domains, and those that operate solely in the digital domain. An example of the former might be innovations associated with the digitalization of automobile control systems in which digital technologies enhance the capabilities of a physical product. Regarding the latter, this concerns innovation in the software industry, in which the product itself is digital. We consider 3DP as a digital innovation that bridges the digital and physical domains, in that innovation occurs both in the software (e.g. digital modelling of objects) and physical domains (e.g. innovation in printing technique and materials).

Data collection

We have collected data through multiple methods. Table 1 provides a summary of the study's data sources. The first author spent at least 3 days a week, on average, over five years, within

the research and development (R&D) group, directly examining and following how hospital actors attempted to scale up the innovation of 3DP, at three distinct places. Our primary data sources include ethnographic observations (400 hours) and detailed field notes (400 pages, single spaced) of how 3DP innovation was developing over time, as well as in-depth, semi-structured interviews with participants from various hierarchical levels and disciplines (55), supplemented by archival data (20GB of project progress documents, emails, technical specifications and design files of 3D printed medical devices, spanning a period of four years.

In addition to the spontaneous, informal interviews that regularly occurred while observing work, we also arranged semi-structured interviews with informants from different hierarchical levels and functional areas involved in scaling up 3DP. Almost all interviews were digitally recorded to facilitate analysis and lasted 30 to 120 minutes, producing 750 pages of single spaced, transcripts.

---------- Insert Table 1 here ----------

Our initial interviews were exploratory; we collected rich data on the organizing practices of the 3DP projects CIG were working on over time by using an open and flexible interview design. We carefully considered and rephrased questions with interviewees so that they could discuss how they experience their work world, what is meaningful to them and what their practices involve, while remaining open to emerging themes. This facilitated the emergence of unexpected themes, such as the importance of place, resourcing and location meaning, which guided our consequent data collection efforts.

We also conducted participant observation and took detailed field notes (Emerson et al. 2011) of the practices of the different groups involved in 3DP in real-time, as well as at several project meetings, where audio-recording was not allowed. As a participant, the first author was granted access to the hospital as an honorary researcher and was physically located at the R&D subgroup, regularly interacting with members of the team and developing several close informants. The honorary researcher role was a natural one to conduct participant observation because the first author was an accepted, yet temporary, member of the organization. The first step in assembling a day's field notes was to expand the running notes taken in the field into full narratives that someone who had not been on-site could understand. Similarly, we indexed screenshots and photocopies of documents at the point in the field notes where they were used.

We paid particular attention to "reproducing the sensation of being there, captur(ing) the nuances of that moments and render(ing) these meaningful (Jarzabkowski et al., 2014, p.276).

We also collected archival data related to CIG's history to further specify and refine events from the interviews and meetings. We received, for example, internal reports, newsletters and emails between all the different actors involved, internal organization documentation such as project specifications, product designs, memos and strategy reports. Complementary to these, we collected public 3DP regulation reports and blog entries from key medical 3DP organizations. These archival sources helped with obtaining historical and reference points for 3DP project dynamics across the hospital and wider 3DP technology updates.

Data Analysis

Parallel to data collection, we proceeded with multiple readings of our field notes, exploratory writing and discussions with colleagues paying particular attention to surprises and puzzles (Abbott 2004). During this process, and as a first step of analysis, we paid attention to the longitudinal nature of our data and adopted a process research approach (Langley 1999), with the aim of tracking the flow of events. The first step of analysis consisted of multiple readings of the interview transcripts, field notes and documentation, the open coding of discursive and other practices, as well as issues related to everyday work at CIG. This led us to employ a multitude of strategies for analyzing the data, such as narrative strategy (Langley 1999, Pentland 1999) and a grounded theory strategy (Strauss and Corbin 1990). Our open coding focused on the everyday practices of the multidisciplinary groups at CIG (Feldman and Orlikowski 2011), such as the R&D practices of rapid prototyping, designing, mechanical engineering practices of equipment management and repairing and the 3DPLab practices of anatomical modelling, while remaining alert to emerging ideas. At the same time, we wrote extensive theoretical memos on our emerging findings and created an event list (Poole et al. 2000) based on our interviews, fieldnotes and archival date. This enabled us to maintain an integrated database of evidence in Atlas.Ti, throughout the fieldwork, which helped us construct a detailed story from our data and identify linkages and patterns between different types of events and practices.

Through this process and over time, we were sensitized to the emerging importance of place, resourcing and location meaning when attempting to scale up the digital innovation of 3DP.

For example, in their descriptions of work, our participants repeatedly referred to the importance of the mechanical engineering workshop place and its role in developing the 3DPLab service. This was further corroborated by participant observations, where we observed tensions and challenges enacted through the practices of the R&D and mechanical engineering subgroups at the workshop place, as well as 3DPLab, and what outcome that brought about for the development of the 3DP innovation. Once place started to emerge as a topic of interest, we went back to our data and mined our field notes, interviews and documents for relevant clues and meaningful events.

In this second round of analysis, we therefore focused our attention on documenting, exploring and unpacking how places were actively shaped, justified, emerged and nurtured during the digital innovation process. We paid particular attention to the resourcing practices used, how materiality was consequential, as well as how location meaning influenced the subsequent scaling of the 3DP service. To do so, we knitted our findings together as rich vignettes; "vivid portrayals […] of specific incidents that illuminate [the] theoretical concepts" that emerged from our analysis (Jarzabkowski et al. 2014, p. 280). Namely, how the 3DP lab was centralized away from surgical departments to avoid territorial disputes (vignette 1), the attempted renovation of the biomedical engineering workshop into a 3DP hub, (vignette 2), and finally, how the neurosurgeons were claiming a distinct, third place away from the hospital (vignette 3).

In the next section, we organized our findings into a conceptualized composition (Berends and Deken 2019), which is particularly appropriate when drawing on concepts from prior literature, when aiming to extend and refine theory. The findings section provides composite narrative theorizing organized in vignettes, showing the resourcing attempts and scaling strategies used by different occupational groups to actively shape and reshape place when scaling 3DP innovation. In addition, we code the sequences of events chronologically to ensure the temporal coherence of the narrative (Berends and Deken 2019). Even though, for analytical purposes, we present each vignette separately, we emphasize the interconnected nature of the events and weave in the dynamic, relational unfolding of places and how they are consequential for scaling up the digital innovation of 3DP.

PLACE DYNAMICS FOR SCALING 3D PRINTING

The analysis follows four key groups involved in the process of scaling up the digital innovation of 3DP. Our findings elucidate three intertwined aspects of scaling as per our theoretical framework, resourcing practices, materiality and location meaning. In this way, we go beyond the view of place as a geographical locale, by examining how resourcing, materiality and location meaning shape and reshape the digital artifact of 3DP with different innovation outcomes. Our first vignette demonstrates the scaling strategies used by the radiologists to challenge surgeons' claim over 3DP, with the aim of centralizing the innovation at a 'neutral' place (see table 2).

---------- Insert Table 2 here ----------

Vignette 1 - The Centralized 3D Printing Lab

Centralizing the 3D printing service: In September 2014, Joanna, ex-plastic surgeon trainee and academic clinical fellow in radiology, prepared a business case to establish an in-house 3DP service at the hospital. As a major trauma center, the hospital required an in-house service to permit the rapid production of anatomical models to aid with surgical planning. Anatomical models were also seen as playing a vital role in the education of patients, staff and medical students. Having changed path from plastic surgery to radiology, Joanna arrived at the hospital in 2013 to start a 5-year registrar training but was surprised to discover this major hospital did not have direct access to 3DP technology. As someone who had vast experience with the technology during her PhD on craniofacial imaging, she took on the role of project leader with her passion for radiological applications improving patient care using 3DP. She justified the case by showing how 3DP innovations could enhance patient care, surgical teaching and training, through the production of anatomical models at a reduced turn-around time and with long-term cost savings.

At the heart of the 3DP business case was the fundamental desire to ensure that all patients and clinicians could benefit from the technology, rather than confining the service to one surgical department. To do so, Joanna argued, it was imperative to establish a centralized 3DP service at a neutral place, available to individuals both within and outside the hospital. For example:

"We are keeping the service out of a department's 'territory', which would result in departmental silo thinking and would not diffuse innovation in the hospital" (Radiologist Interview, 2016)

Joanna managed to convince the surgeons that centralizing the 3DP service would be essential to its effective implementation. She justified a centralized place to keep the service out of surgeons' "territory", which she argued would result in departmental silo thinking and prove problematic for scaling up the innovation in the hospital.

In conjunction to claiming a centralized place for the 3DP service, Joanna also justified the introduction of 3DP in terms of the key resourcing needs of the hospital. She argued that centralizing the service involved "generating income through the service and reinvesting it to buy the next 3D printers". They chose to centralize the service at a lab in the basement of the hospital, which served as the hospital's central graphic design and print studio, because of its established role as a central service provider for the hospital. They justified this decision as the lab was equipped to cross-charge medical specialties for services both within and outside the hospital, something which no other department was equipped to do. Therefore, centralizing the 3DP service at a 'neutral place', at the basement of the hospital, was intimately connected to resourcing practices of cross-charging, which is critical for spreading the innovation of 3DP across the hospital.

Broadening 3D printing practices: The second scaling strategy used by the radiologists and the traditional photography studio at the hospital involved resourcing attempts of enrolling a wide range of departmental partners beyond surgery, focusing on radiology expertise in 3DP and creating a new occupational role of the 3DP technician. An excerpt from our fieldnotes demonstrates the enrolling of departmental partners:

"The radiologist (project leader) initially met with the hospital divisional director and the director of R&D finance, who helped in contacting other people in the hospital interested in 3D printing – this included the clinical engineering department, neurosurgeons and maxillofacial surgeons" (Fieldnotes, 2016).

In doing so, not only did she argue the 3DP service requires an inherently multidisciplinary team to work with, but also linked the innovation to radiological expertise:

"Radiology needs to be central [for 3D printing work] … you must have a central imaging service, without this, 3D printing would not work, all the occupations involved need to have a

shared understanding of how things work to facilitate collaboration and knowledge exchange through radiology".

Finally, the radiologist argued that having a full-time dedicated technician to run the service, who would be able to perform all aspects of 3DP, was vital. To justify this new occupational role, she noted that complex segmentation practices necessary for the creation of 3D models were incompatible with the workload of clinical staff. The scaling strategies used were successful for justifying an in-house 3DP lab servicing both internal hospital departments and external clients – servicing the wider biomedical campus ecosystem. In doing so, she succeeded in placing the 3D printers at a 'neutral place', that is, a place where they thought no hospital division, surgical specialty or departmental politics would influence the use of 3DP.

The digital artifact of 3DP: Locating the 3D lab at a 'neutral' place down at the basement of the hospital shaped the use of the 3DP over time. For example, because the 3D lab was servicing the wider biomedical campus, they developed an anatomical modelling practice, based on segmenting CR or MR images. This meant they could design and 3D print devices in house for the benefit of all hospital departments. By taking advantage of recent technological advances in MRI and 3D ultrasound, the 3D lab utilized 3D images of human body structures to create 3D models of patients' anatomy. A digital infrastructure was setup for the 3DP practices of the service. The imaging datasets were obtained from radiology in their raw format (DICOM data) and were imported into specialist software packages. The structure was identified and turned from sliced imaging into a 3D structure, by engaging in segmenting practices, which could be rotated and edited on screen. The software then produced a stereolithographic (stl) file, required to communicate with the 3D printer software. Once modelled using CAD software, further adjustments could be made in terms of coloring and sizing, and the finished file was sent to the 3D printer. The surgeons – end users of the anatomical models created at 3D lab, did not have the segmenting skills necessary to create the models, which made the 3DP process a highly interdependent one, between surgeons and 3D technician. However, the physical separation and distance between the 3D technician down at the basement and the surgeons, who were located at different floors throughout the hospital, made it difficult to coordinate.

Location meaning: By June 2017, the place where the 3DP service was established, at the basement of the hospital, was clearly influential to the (failed) scaling of the service. First,

the clinical engineering innovation group (part of biomedical engineering) often noted that the centralized 3D anatomical modeling practice was illegitimate and lacked in accountability protocols. They often called the 3D lab "medical photography", as they did not think they were using the appropriate governance to assure the quality of the 3D printed items. The 3D lab acknowledged these concerns:

> *"3D printing being a part of Medical Photography, which is a video, editing and photography department, might be subconsciously leading people to think that is not an innovative service in that sense" (Head of 3D Lab Interview, 2017)*

To provide quality assurance on any medical device, the clinical engineers argued, there had to be the appropriate traceability of material, calibrating, storing of data and the technical file, work instructions for thresholding & CT scans with which the medical devices were designed. Additionally, they thought 3DP items count as medical devices, in which case, the 3DP Lab technician working at the 3D lab did not have the appropriate "band" (level of seniority) and skills to deal with. Second, the location of the 3D lab down in the basement mattered. In healthcare, labs are usually located close to surgeons to produce collaboration that would otherwise not be facilitated. As the 3D lab was located far away from the main users of the 3DP in the hospital, the surgeons, demand for the service was low and contributed to financial difficulties for running the service. The physicality and materiality of the 3D lab located at the basement of the hospital were consequential for the failed scaling of the service, which eventually entered into a period of financial challenges. A senior manager at the hospital was particularly critical of the location of the 3D lab at the traditional photography services studio: *"The photography studio is just that, photography is not a design studio for medical equipment. That place means I get photographs done and slides done, posters, it does not mean I can do 3D printing. I am confused, the 3D printing lab should be under Medical Engineering, you know, you don't send a request to print a skull down to photography studios that does not make any sense to me"*

In view of the financial challenges facing the 3D lab, the biomedical engineers engaged in scaling strategies to renovate their own mechanical workshop into a 3D lab where surgeons would be integral to the process through consultation in the innovation process. We explore these dynamics in the second vignette below (also see table 3).

---------- Insert Table 3 here ----------

Vignette 2 - Renovating the Mechanical Engineering Lab

The second vignette examines how the biomedical engineers engaged in resourcing attempts to renovate their own mechanical workshop and merge it with the centralized 3D lab at their own location of choice. The financial difficulties of the 3D lab were an important junction for biomedical engineers to shift power established at one scale (the 3D lab) and extend it to another (their own mechanical workshop).

Renovating facilities into a 3D Printing Lab: The biomedical engineers proposed to revamp their mechanical workshop into a future proof, in-house prototyping and 3DP facility that complemented the 3DP lab, in the hope of scaling up innovation work within the hospital. The engineers prepared an innovation project brief to gather investment for updating the existing mechanical workshop place, which, as they phrased it, had some outdated and redundant kit that could be removed, providing space for rapid prototyping facilities, quality-controlled manufacturing areas and meeting spaces. In other words, R&D advocated renovating the workshop place for "inspiring innovation through building a creative and safe environment for design, prototyping and manufacture of medical technology". Key to their business proposal to revamp the mechanical workshop was meeting the current and projected resource needs of biomedical engineering. They justified their argument by demonstrating how the revamping of the workshop would help with current and future staffing needs (including training, apprentices, internships and academic placements) as well as update and future-proof the hospital's in-house prototyping and manufacturing facilities. Renovating the mechanical workshop was a main attempt by the biomedical engineers at becoming more frontstage actors in hospital innovation work.

Co-opting centralized 3D printing lab with biomedical engineering: In addition to renovating facilities, the biomedical engineers also appealed to quality assurance and regulatory requirements, as well as promoted their engineering skills to clinicians in the hospital. First, the engineers argued that in accordance with quality assurance requirements, "*redundant equipment is being identified which will make some space available to accommodate the renovation"*

Location meaning: Second, they argued that their practices of seeking unmet clinical needs in the hospital would be facilitated by the renovated 3DP innovation hub. In other words, they envisioned a place where the mechanical workshop would no longer be a place of renovating equipment, but a "future proof" 3DP lab for scaling up innovation work and fit for

purpose to meet current and future hospital demands. To do so, they invoked a reconfiguring of the materiality of the place to remove 'redundant equipment' to provide space for 3DP facilities, quality-controlled manufacturing areas, as well as meetings and office space. Intimately connected to the materiality of the place in general was the materiality of the 3DP artifact. For example, the renovation would clear out space for 3D printers to be installed, as well as software licenses purchased to do 3DP work.

However, their scaling strategy backfired with unintended consequences. Although the R&D subgroup of biomedical engineering aspired to design this collaborative place, the mechanical engineering subgroup resisted this change. The innovation project brief resulted in discursive practice tensions between the R&D and mechanical engineering subgroups, based on their different disciplinary practices. The mechanical workshop place was consequential for these tensions, connected to the materiality and location of the workshop, and eventually the project was not approved. After consultation with technologists and technicians in the group, the head of mechanical engineering concluded that the innovation proposal was only addressing the desires of the R&D subgroup. Mechanical engineering wanted to maintain the place they had for their repairing and equipment managing practice, for which they were invested in as to how they added value at the department and across the wider hospital. The materiality of the mechanical workshop included an array of milling, drilling and computer numerical control machines, along with trolleys and other medical equipment for repair, as seen in Figure 2 below. Specifically, mechanical engineering signaled the need for maintaining the group's equipment repairing practice and hence, their identity as 'equipment fixers'. The discursive practice tensions around the vision, artifacts and disciplinary practices of the mechanical workshop stalled and thwarted the innovation process for advancing 3DP use in the hospital, by means of developing the services of the 3DPLab.

---------- Insert Figure 2 here ----------

Although the attempt to renovate the mechanical workshop failed, another multidisciplinary team of neurosurgeons collaborated with the biomedical engineers to frame another place for scaling 3DP, which we explore below (also see table 4).

---------- Insert Table 4 here ----------

Vignette 3 - Commercializing 3D Printing Work

Commercializing 3D printing work as a spin-off organization: The starting point for this scaling strategy was the commercializing of a 3DP process that creates custom made cranial plates for patients undergoing a craniectomy procedure. The vignette exemplifies the how the neurosurgeons, sought influence over the 3DP service by attempting to create a new category of care outside the hospital. Their scaling strategy was focused on redefining whose jurisdiction 3DP belongs to. The following excerpt from field notes provides details of a key meeting:

> *This was one of the most important meetings of the week. The multidisciplinary team of biomedical engineers and neurosurgeons are using 3D printed titanium plates to replace parts of patients' skulls, which were previously hammered out by hand and adjusted during surgery with an imperfect fit. The neurosurgeons developed a standardized process that utilizes in-house computer aided designs of patient specific implants from CT scans, and their external manufacture using titanium laser sintering within a clinical ward. The meeting was setup to decide whether to commercialize the 3D printed cranial plates by creating a spin-off organization, or whether to keep the service in-house. The biomedical engineers argued that keeping the service in-house would provide regulatory control as they already have an established quality management control system in place. The neurosurgeons, on the other hand, while they agreed that control is essential to the process, they highlighted resourcing concerns over the management of the 3D printing service. John, the neurosurgeon in charge, argued that the hospital should be kept out of this process, so they could commercialize the 3D printing service using a spin-off company. "What I don't want is for our funds to get lost in the trust, we want to be able to make some money to fund further 3D printing work and keeping the service in-house will not help us do that", he said. This would provide the necessary freedom to operate commercially without the constraints of bureaucracy at the hospital. This was because they feared that keeping the service in-house would make it difficult to manage their funds the way they wanted. There was much to consider in terms of resourcing and placing the 3D printing service going forward.*

The neurosurgeons' push towards commercializing the 3D printed cranial plates into a spin-off organization was a resourcing attempt to re-invest the potential profit from the 3DP service externally, without getting lost into the 'red tape and bureaucracy' of keeping the service in-house, within the hospital. It was clear that the neurosurgeons felt restricted and constrained by the organizational structure of the National Health Service (NHS). Even though a centralized 3D printing lab was established for the benefit of all surgical specialties, the neurosurgeons claimed their own technique based on user generated innovation, along with key resourcing attempts around the funding and management of the service externally. At the

same time, they proposed a complete reconfiguring of the materiality of the 3DP lab as a spin-off place external to the hospital, in conjunction to a brand-new location.

Location meaning: However, the biomedical engineers and radiologist with the 3D lab viewed the new location as a 'dirty place' and disagreed with the commercialization under a spin-off. Joanna wanted to protect the centralized 3D lab she had fought hard to establish to avoid 'territorial disputes', as well as the importance of the radiological expertise which she claimed were integral to the success of the 3DP innovation.

More importantly, the biomedical engineers raised concerns about the legitimacy of such a spin-off – in terms of "money laundering". The head of biomedical engineering commented:

"*You can't have the money coming out from the hospital and being received by another body. For a financially stretched hospital, like ours, this is very important. We have a cost improvement program in place and have to meet the requirements. If the expenditure is higher than the income for the service, then it's a problem"*

The biomedical engineers also challenged the control of the service in terms of regulatory requirements, based on the biomedical engineering disciplinary practices. The engineer who attended the commercialization meeting commented:

> *"I don't think it's going to work outside - we want to have the service inside the hospital [...] I have concerns over control. We have the regulatory requirements inside, whereas we would have to get the regulations outside…this would require setting up a quality system that has significant costs associated… it will be much tighter inside…branded and marketed by us".*

Although the neurosurgeons were framing a place for 3D printing that would serve the NHS more broadly, by using a scaling strategy to commercialize the 3D printing service into a spin-off organization outside of the hospital, their attempt at reconfiguring the materiality and location of the 3D lab failed.

A Process Model of Place Dynamics and Scaling Digital Innovation

From our study, we sought to develop an understanding of how scaling happens in digital innovation, as well as how and why scaling eventually failed on three different occasions. Generalizing our insights, we formulate a theoretical model of scaling digital innovation

(Figure 3). The model contributes to the digital innovation literature by identifying and theorizing the role of resourcing, materiality and location meaning structures in scaling innovations. In addition, we show how place shapes, and is shaped by the digital artifact of 3DP. As such, the model elaborates how place and scaling are consequential for innovation outcomes in three different ways.

---------- Insert Figure 3 here ----------

Our first vignette demonstrates the theoretical concept of *place bending* - scaling strategies used by the radiologists to challenge surgeons' claim over 3DP, with the aim of centralizing the innovation at a 'neutral' place. Bending place emphasizes claims on who is more efficient in operating 3DP. To do so, the radiologists challenged surgeons' claim over 3DP and eventually managed to centralize the 3DP service with the 3DLab, located at the basement of the hospital. This meant that the materiality of the 3Dlab was configured in a specific way, through practices of anatomical modelling and segmenting models for in-house 3DP, to service the wider biomedical campus ecosystem.

In this way, 3DP and location, as a unit, became a specific set of possibilities. For example, through the anatomical modeling practice at the 3Dlab, in-house 3DP was made possible, by placing specific 3D printers at the lab. This was only possible because of the neutrality of the place and the resourcing the radiologists engaged in. Cross-charging for 3DP services across the biomedical campus was only possible by associating 3DP with the traditional photography studio of the hospital. However, the location of the place was highly symbolic – underpinned by political meaning and inadvertently exposed to politics (Lefebvre 1991). The 'neutral' location away from any specific surgical specialty was interpreted as illegitimate by the biomedical engineers and managers at the hospital. Over time, the 3D lab entered into financial difficulties as the service was underutilized.

The second vignette demonstrates *place jumping* - scaling strategies used to challenge claims and power established at one place and extend them to another place. For example, following the period of financial challenges at the 3D lab, the biomedical engineers utilized specific resourcing practices with the aim of renovating their own facilities and co-opting the centralized 3D lab. When engaging in *place jumping*, the biomedical engineers were pulling resources centrally by proposing to renovate the materiality of their mechanical workshop, as well as create a new location for 3DP at the hospital. Due to the strapped resourcing of the biomedical engineering team, the engineers could not afford to develop the anatomical

modeling practice of the 3D lab. In addition, because their mechanical workshop was cluttered with industrial equipment, they did not have the space available to use 3DP in-house for printing devices, which meant they would outsource 3DP, while retaining the development of models in-house.

Finally, the third vignette demonstrates *place framing* - scaling strategies used to foreground or background particular issues by locating them at different places. For example, the neurosurgeons attempted to create a new category of care outside the hospital with a focus on redefining the jurisdiction 3DP belongs to. The commercialization of 3DP as a spin-off to serve the NHS as large was based on re-investing income from the service externally to a different location, as the neurosurgeons felt constrained and restricted by the in-house 3DP place. This meant that they could focus on the design of medical devices and outsource the 3DP. However, this place was interpreted as a 'dirty' place by the biomedical engineers and radiologists, due to what they referred to as 'money laundering' concerns. Once again, the location was symbolic and consequential. As Navaro-Yashin (2009) argues, places are affective agents and can engender unintended responses. In this case, the 'money laundering' concerns evoked affective responses that were consequential to the scaling of the digital innovation, leading to the eventual abandonment of the commercialization.

Overall, our theoretical model demonstrates that scaling is a continually unfolding and emerging process in digital innovation which involves various attempts to grow in different places. In all three cases, the place dynamics were intimately related to the materiality of the place, its symbolic location based on politics, as well as what 3DP artifact was becoming, leading to further scaling strategies. Even though place bending helped establish the 3D lab at a neutral place, over time, the practice clashes led the centralized 3DP lab to financial difficulties. As a result, the biomedical engineers attempted place jumping through resourcing attempts to renovate their own mechanical workshop and co-opt the centralized 3D lab at their own location of choice. The financial difficulties of the 3D lab were an important junction for biomedical engineers to shift power established at one place (the 3D lab) and extend it to another (their own mechanical workshop). However, this led to practice clashes with the mechanical engineers, whose repairing practice was intimately connected to the workshop place. Eventually, the place jumping attempt by the biomedical engineers failed. Following this failure, the occupational group of neurosurgeons attempted place framing, to commercialize the 3DP work as a spin-off organization outside the control of the hospital. This led to affective responses by the biomedical engineers around legitimacy and regulatory control, who raised

concerns over ‘money laundering’ with the commercialization of 3DP as a spin off outside the hospital.

DISCUSSION AND CONCLUSION

In this paper, we have addressed the question of how places matter in the digital innovation process, and with what implications for scaling. Through a five-year long fieldwork study, which focused on the case of 3DP at a major NHS hospital, we elaborate theory on the continued importance of place and its significance with the digitization of innovation. We synthesize our findings into a theoretical model that theorizes the role of resourcing, materiality and location meaning structures – intimately connected to political considerations and power, in digital innovation.

Scholars of digital innovation argue that scaling digital ventures is qualitatively different from the scaling documented in classic case studies (e.g. Chandler, 1962). The assumption is that with the leanness with which digital ventures grow by drawing on and adding to digital infrastructures helps to increase the speed of scaling. Previous works suggests three mechanisms: data-driven operation, instant release, and swift transformation that underpin the generative process of rapid scaling of innovations. However, in this study we show that scaling entails considerations of place as well. Our model shows how these considerations shape and are shaped by the digital artifact of 3DP, constitutive of the scaling attempts by the occupational groups in our study and consequential for innovation outcomes. Our research has implications for the digital innovation literature and scaling, which we unpack below.

Place Matters in Digital Innovation

First, our study has implications for the emerging stream of research that examines the role of place in innovation. Albeit implicitly, earlier work has shown that where technologies are placed leads to different outcomes (Barley, 1986), and how the hybrid materiality of the place of digital innovations can shift boundary relations (Barrett et al., 2012). More recently, studies emphasize how places can have profound consequences for the actors involved, their practices and the outcomes of innovation processes (de Vaujany and Vaast, 2013; Lawrence and Dover, 2015). Nonetheless, the role of place in digital innovation remains nascent in theoretical and empirical work. One exception is the study by Oborn et al., (2019), who take a broader view

of distinct geographical places associated in local practices, materialities and values necessarily shape and possibly transform the trajectory of innovations over time. Our research builds on this emerging stream of research and contributes by further refining how places are implicated in the digital innovation process. For example, our theoretical model goes beyond the view of place as a geographical locale and theorizes the constitutive role of resourcing strategies, materiality and location meaning, which taken together, explain *how* and *why* the digital innovation of 3DP failed to scale up and grow in three different places. At the same time, our study departs from previous research by examining longitudinally the attempted scaling in three different places within the same hospital. In particular, we, theorize how 3DP was becoming a different set of possibilities over time through resourcing practices, materiality reconfiguration and symbolic location meaning. As such, we suggest that place is an important material dimension that is often overlooked, and that place, being relational, can influence the materiality of digital innovations such as 3DP, which has integrated digital and physical components.

Second, our research has implications for research regarding the organizing of digital innovations, a question that is critical for organizations which operate increasingly in a world that is permeated with digital technology (Yoo et al. 2012). We show how places remain important despite the digitization of innovation. Digital innovation scholarship should pay more attention to local places, materiality and how their location meaning are constitutive of implementing digital innovation. Relatedly, our study also has implications for the emerging focus on materiality in digital innovation (Barrett et al. 2012, Cecez-Kecmanovic et al. 2014, Leonardi and Barley 2008, Orlikowski and Scott 2008). While studies have focused on the digital materiality of technological artifacts, such as remote diagnostic systems (Jonsson et al. 2009) and the digital and mechanical materialities of robots (Barrett et al. 2012), we show that the materiality of the situated places of implementing digital innovation, as well as the continually unfolding location meaning, intimately linked to power dynamics, are crucial elements in scaling digital innovation.

Placing Strategies for Scaling

Previous research has highlighted that generativity and convergence can enable digital innovations to grow and scale rapidly in unprecedented ways (Huang et al. 2017; Henfridsson and Bygstad 2013; Yoo et al. 2010). Our findings allow us to make sense of the processes underpinning the scaling of innovation (Huang et al., 2017), as evidenced by the unexpected

outcomes in the scaling of 3DP. Oborn et al. (2019) argue that scaling is an emerging, deeply contextualized process in space and time. Our study resonates with this view and further elaborates how places are consequential for scaling. For example, our theoretical concepts of place bending, jumping and framing are intimately connected to scaling, but do not guarantee the scaling of the digital innovation of 3DP. Relatedly, Bansal et al. (2018) note that scale is confounded with size in organization and management scholarship. Instead, they argue that "scaling up" requires a fine-grained understanding of local spaces rather than simply "sizing up" across different geographies. Our process model shows the importance of local places for scaling digital innovation. Through place dynamics such as place bending and framing, we go beyond the common expectation that scaling requires jumping from one geographical locale to another.

We note that our findings are limited to the extent that we only examined the distinctive digital innovation of 3DP in a specific geographical locale, albeit over a number of years. In addition, by negotiating access to the field site through the R&D department, it was increasingly difficult to obtain access and observe the surgical practices of using 3DP in practice. This provides fruitful opportunities for future research. For example, future work can more closely examine areas such as surgery and surgical planning practices, to gain a more granular understanding of how the innovation of 3DP is implemented in practice.

FIGURE 1:

ORGANIZATIONAL CHART OF CLINICAL INNOVATION GROUP (CIG)

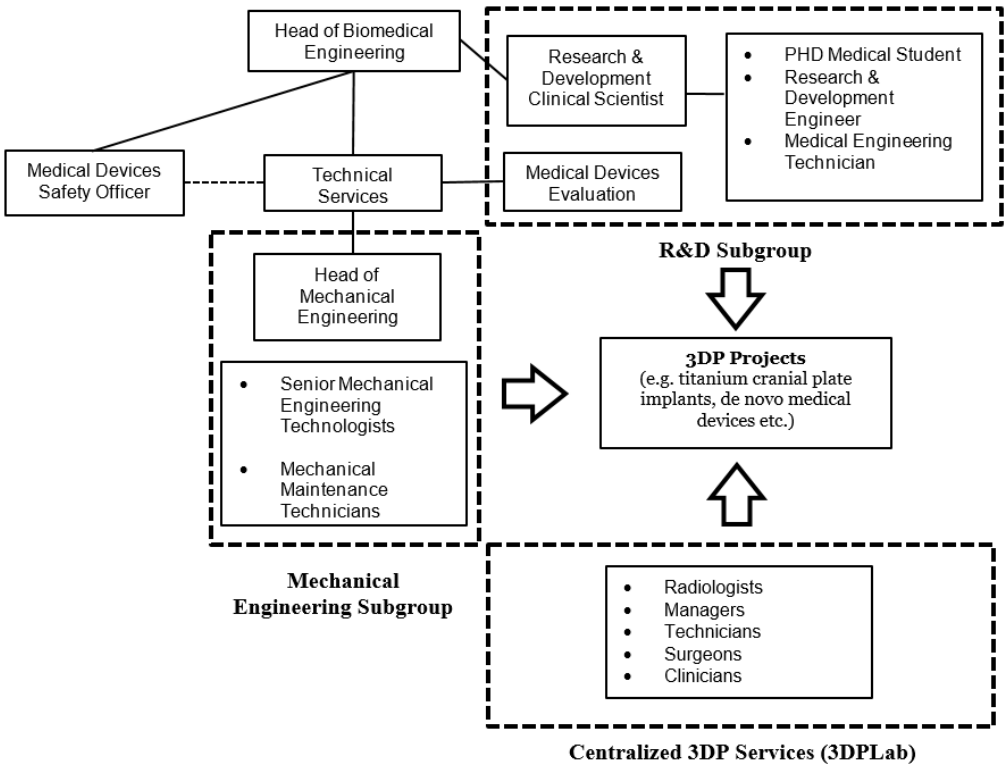


TABLE 1

DATA SOURCES

Data Collection	Informants/Material	Total
Semi-structured interviews	**Formal (#55) with 48 participants, including:** Hospital Divisional Directors, Managers, Clinical Scientists, Clinical and Mechanical Engineers, Technicians, 3DP healthcare professionals, Surgeons, Radiologists **Informal (#100) with participants above during fieldwork**	60 hours 5 interviews conducted over Skype 250 hours 17 months of observation
Participant observation	**Meetings** ● Design review ● Establishing and updating 3D projects **Biomedical engineering** ● Rapid prototyping ● 3D modelling ● Repairing and maintaining equipment **3DPLab Practices** ● Anatomical modelling ● 3DP of medical devices	40 hours 150 hours 50 hours 400 pages of field notes, single spaced
Archival sources	**Emails** ● Evolution of practices between 2014-2019 (through branding materials, plans, logos, interactions)	100
	Internal documents ● 3DP device technical specification files ● Design drawings ● Project review documents	150
	Public documents ● Medical regulation and legislation directives ● 3DP Reports ● 3DP blogs	100

TABLE 2:

PLACE BENDING

Place Dynamics	Scaling Strategies	Resourcing	Exemplary Quotes
Place Bending (Emphasis on who is more efficient in operating 3D printing) • Aim is to challenge surgeons' claim over 3D printing • 3D printing not tied to specific surgical departments	**Centralizing 3D printing service**	Justifying the need for a centralized, in-house 3D printing service at a 'neutral' place	*"It wasn't just because of our cost recovery organizing structure… if you locate the printers under craniomaxillofacial, it would integrate with them, hence we placed it in a neutral place to keep the service open to all surgical specialties (Head of 3D Lab Interview, 2016)* *"The optimal service should be fully centralised to encourage use by all departments both within and outside of the hospital" (Public Document, 2016)*
		Cross-charging hospital departments and external clients	*"For a successful centralized service, the [photography and graphic design lab] is the optimal umbrella under which 3D printing should fall. The lab is already equipped with the ability to cross-charge specialties for services, and is available to all individuals and departments both within and outside of the hospital" (3D Lab Business Case Document, 2015)*
		Reinvesting income to grow service	*"Centralizing the 3D printing service means we can generate income through the service and reinvest it to buy the next 3D printers" (Fieldnotes 2016)* *"By producing the models in-house the hospital benefits from reduced costs compared to professional external companies, and potential cost-savings through reduced surgical time and improved patient outcomes" (3D Lab Business Case Document, 2015)*
	Broadening 3D printing practices	Enrolling departmental partners	*"An application has been made to the Innovation Fund, to provide funding for a technician who will run the service full-time for the first 2-year period. This will allow the service to be established. On-going staff funding will be provided via cost-recovery through the cross-charging of models" (3D Lab Business Case Document, 2015)*
		Focusing on radiology expertise in 3D printing	*"At the center of the project is the common requirement for imaging (radiology), and a need for easy transfer of the imaging DICOM data for which*

			I am well placed. With a surgical background, I offer a unique mix of radiological and clinical experience to ensure that clinicians are able to fully utilize 3D printing" (3D Lab Business Case Document, 2015)
		Creating a new technician role	*"The hours spent completing complex segmentation are often incompatible with the workload of clinical staff [...] as a result, having a full-time dedicated technician to run the service, who is able to perform all aspects of 3D printing, is vital" (Radiologist Interview, 2016)*

TABLE 2
PLACE JUMPING

Place Dynamics	Scaling strategies	Resourcing	Exemplary Quotes
Place Jumping (Emphasis on shifts in patterns of action on the part of higher-level actors in the hospital) - 'claims and power established at one geographical place are extended to another place.	**Renovating facilities into a 3D printing lab**	Clearing the biomedical engineering mechanical workshop into an innovation space	*"We wish to scale up the innovation work in the hospital. For this, there needs to be significant investment in improving and updating the working environment and facilities. There is an existing Mechanical Workshop which has some outdated and redundant kit which, if removed, could provide space for rapid prototyping facilities, clean room, quality-controlled manufacturing areas, meeting spaces, office spaces and potentially a usability lab" (Innovation Space Project Brief Document, 2016)*
		Requesting funding from external partners	*"We would like to work with [hospital funding agency] to raise funding to bring this innovation space into reality, to value this pioneering team and to provide a resource which will serve the hospital for many years to come" (Clinical Engineer Interview, 2016)*
		Staff resource prospecting	*"We need to accommodate current and projected resource needs, such as staffing (including training, apprentices, internships and academic placements), & update and future-proof in-house prototyping / manufacturing facilities" (Innovation Space Project Brief Document, 2016)* *"The renovated lab will be a positive and inspiring working environment to demonstrate that staff is valued" (Clinical Engineering Manager Interview, 2016)*
	Co-opting centralized 3D lab with biomedical engineering (asserting task jurisdiction)	Appealing to quality assurance, risk and regulatory requirements	*"Quality assurance and regulatory requirements indicate that space needs to be updated to be fit-for-purpose (to meet current demand), and future-proofed for scale-up of innovation work. (Innovation Space Project Brief Document, 2016)*
		Replacing 3D lab location	*"The 3D lab technician and the whole centralized 3D printing service should move to R&D, I don't think the basement is the right place for it" (Head of Financing Interview, 2017)*

		Promoting engineering skills to clinicians	*"The innovation lab will help translate engineering research into clinical practice through an inside-out model of innovation; seeking out unmet clinical needs in the NHS and designing solutions through the application of science and engineering" (Clinical Engineer Interview, 2017)*

TABLE 3
PLACE FRAMING

Place Dynamics	Scaling Strategies	Resourcing	Exemplary Quotes
Place Framing (Emphasis on discursive practices as attempts to foreground/background particular issues by locating them at different scales) • Seeking of influence through scalar discursive practices • Neurosurgeons attempt to create a new category of care, outside the hospital • Focus on redefining whose jurisdiction of care 3D printing belongs to	**Commercializing 3D printing work as a spin-off organization across the NHS**	Commercializing the 3D printing service in a spin-off organization	*"The hospital should be kept out of this process, so they could commercialize the 3D printing service using a spin-off company. What I don't want is for our funds to get lost in the trust, we want to be able to make some money to fund further 3D printing work and keeping the service in-house will not help us do that" (Fieldnotes, Commercialization Meeting#1, 2016)* *"A spin-off organization would provide the necessary freedom to operate commercially without the constraints of bureaucracy at the hospital" (Neurosurgeon Interview, 2016)*
		Reinvesting income externally	*"What I don't want is for our funds to get lost in the hospital. We want to be able to make some money. Science is great, but we also want to commercialize this to fund further 3D printing work" (Fieldnotes, Commercialization Meeting #1, 2016)*
		Claiming cost benefits of 3D printing through user generated innovation	*"Fundamentally, 3D printing provides cost savings. The hospital is now paying £2000 per [cranial] plate. We can make the plates for about £900, using 3D printing work" (Neurosurgeon Trainee Interview, 2016)* *"Using 3D printing, the cranial plates are better-tailored and implantable. The manufacturing process (metal laser sintering) is very fast, which is key for the process […] the customization benefits of 3D printing are more direct, we do*

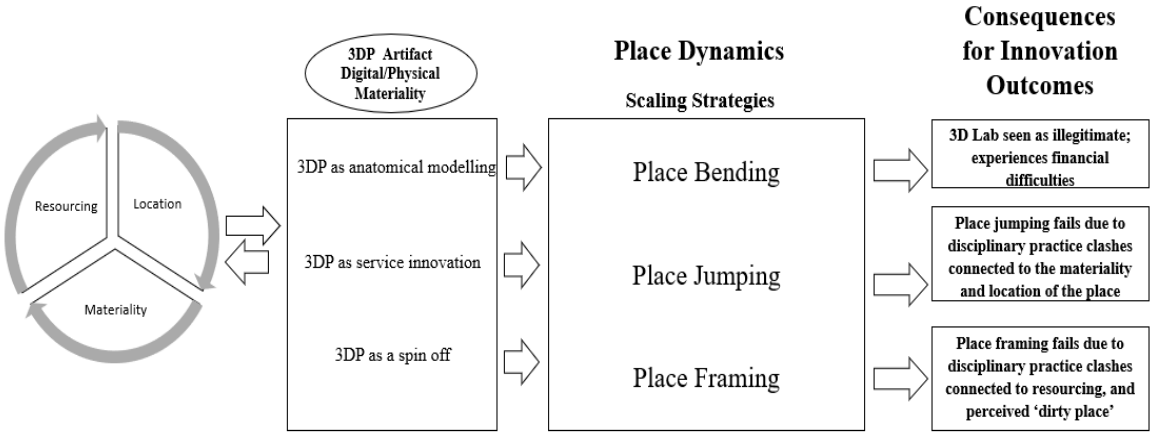
			not use surface interpolation algorithms to design the plates, but rather focus on creating the plate based on patient scans" (Fieldnotes, Commercialization meeting #2, 2016)

FIGURE 2:

THE MECHANICAL ENGINEERING WORKSHOP AT CIG

FIGURE 3:

PLACE DYNAMICS AND SCALING OF DIGITAL INNOVATION



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Paper Three

Pebble in Still Water: How Implementing 3D Printing Reconfigures Jurisdictional Boundaries

ABSTRACT

This paper examines how occupations mobilize, expand or defend their jurisdictional boundaries when a new digital innovation creates upheaval at work. We report on a two-year, longitudinal qualitative study of how medical 3D printing – a technology that transforms digital models into physical objects – was implemented in a UK hospital organization. We adopt a practice lens for examining boundary work practices as enacted by different occupational groups, viewing boundaries as relational, dynamic, and in a state of becoming. We focus on how jurisdictional boundaries are challenged over time; how new competencies are developed, new roles established, status and legitimacy challenged or reinforced and with what occupational consequences for the groups involved. Our findings highlight the ongoing jurisdictional contestations between four groups, presenting an opportunity for unpacking how the materiality of artifacts and spaces is constitutive of the way occupations mobilize, maintain and expand their jurisdictional boundaries.

Keywords:

Occupations, boundary work, collaboration, practice lens, materiality, 3D printing, healthcare

Brain surgery is changing. Surgeons are using 3D printed titanium plates to replace parts of patients' skulls… before 3D printing, metal plates were hammered out by hand and adjusted during surgery, but their fit was not perfect, and up to one in 10 patients developed infections. One of the first patients to have a 3D printed plate fitted, who collapsed with an aneurysm and needed emergency surgery to fix blood vessels in her brain, shared that "I don't feel like I am sort of a monster [chuckles], I am very pleased with the way it looks and the way it feels" (BBC, 2017)

As the excerpt above illustrates, 3D printing (3DP) has gained much interest in the medical world and is widely viewed to have great potential to improve patient lives. Heralded as the third industrial revolution (Economist, 2012), this emerging technology transforms powerfully digital models into physical objects. Implementing 3DP at work, however, is challenging. Prior research on technological innovations has reported that they play an important role in reorganizing work among different occupational groups. For instance, by serving as an occasion for social reorganization (Barley 1986), triggering jurisdictional disputes and renegotiations (Barley, 1996) and shifting identities (Barrett & Walsham, 1999), occupational roles (Bailey, Leonardi, & Barley, 2012; Zuboff, 1988), and boundary relations (Barrett, Oborn, Orlikowski, & Yates, 2012).

New technology implementation may be particularly challenging as cognitive, social, political and knowledge boundaries can inhibit the spread and use of innovations (Ferlie, Fitzgerald, Wood, & Hawkins, 2005). Occupational groups may use technological innovations to engage in boundary work (Abbott, 1988; Gieryn, 1983) in an attempt to provisionally establish, defend, maintain or expand their jurisdictional boundaries and expertise (Barrett et al., 2012). As such, occupational groups draw on their knowledge and expertise to establish and maintain authority over which tasks to perform (Abbott, 1988; Anteby, Chan, & DiBenigno, 2016) and use artifacts to strengthen their knowledge, authority and legitimacy claims during conflictual encounters (Bechky, 2003a).

Despite the noteworthy focus of these studies, previous work has given relatively limited attention to the role of materiality in boundary work (Langley, Lindberg, Mork et al., 2019) . Notable exceptions include Burri's (2008) analysis of how radiologists used physical space to consolidate their jurisdiction over other imaging technologies and Bechky's (2003a) study of artifacts as "representations of occupational jurisdiction". However, we know less about how both physical spaces and artfacts together influence boundary work, when a new technology is introduced to the workplace. In the most complete systematic review of boundary work across

groups, occupational groups and organizations, Langley et al., (2019) call for greater attention to materiality in boundary work going forward. Examining how material and technological artifacts together with physical spaces might reveal how the two can serve as allies or hindrances in competitive boundary work, as well as how changing technologies might shift these dynamics.

This path seems fruitful to explore further. This is especially the case with digital innovations such as 3DP, which require collaboration amongst diverse occupational groups with different disciplinary, knowledge boundaries and expertise, embedded in a web of clinical fields, practice patterns and different technologies (Mol, 2002). Contemporary workplaces are likely to include multiple occupational groups with a diversity of interests, values, competencies and practices, which nevertheless require an increased emphasis on multidisciplinary collaboration. As such, examining the relationality of boundary work and looking at interactions not simply between two groups, but between multiple groups negotiating complex arrangements, is important for generating new insights in this area (cf. Barrett et al., 2012). We therefore examine *how do occupations engage in competitive boundary work practices with the introduction of a new digital innovation at the workplace?*

The purpose of this paper is to extend theory (Locke, 2001) on how occupations enact boundary work practices with the introduction of a new digital innovation. We report on a longitudinal, 24 month long qualitative study of how occupational groups engaged in competitive boundary work using 3DP in a hospital. We focus on how their jurisdictional boundaries are challenged over time; how struggles to obtain status and expand task jurisdictions are negotiated in practice, new work task domains established, authority and legitimacy challenged or reinforced and highlight the consequentiality of boundary work practices for their status and boundaries.

To do so, we adopt a practice lens for examining boundary work as enacted by different occupational groups with the introduction of 3DP in a hospital setting (Feldman & Orlikowski, 2011; Nicolini, 2012). Such a lens conceptualizes boundaries as relational (Abbott, 1995), looking at the dynamic, unfolding relations between groups in a continual state of becoming (Tsoukas & Chia, 2002), and pays attention to material aspects of boundaries and how these may be reconstituted through the introduction of 3DP. In taking a relational approach to boundary work, we highlight the role of materiality which plays an active role in negotiating, embodying, or downplaying boundaries (Barrett et al. 2012; Kaplan et al. 2017; Kellogg et al. 2006; Levina and Vaast 2005; Lindberg et al. 2017). We go beyond a conception of boundary

objects as static devices for communication across preexisting boundaries, to showing how materiality is directly implicated in their constitution and negotiation. For the purposes of this paper, we conceive practices as recurrent, materially mediated, and situated activities (Schatzki, Knorr-Cetina, & Savigny, 2001), organized as sociomaterial sayings and doings guided by practical concerns (Nicolini, 2012) that are consequential in producing and reproducing boundaries (Feldman & Orlikowski, 2011). In this way, we examine how situated, material practices are configuring, maintaining and extending boundary relations through jurisdictional claims, leading to boundary reconfigurations.

We contribute to the literature in two ways. First, our findings unpack how the materiality of artifacts and spaces is constitutive of the way occupations mobilize, maintain and expand their jurisdictional boundaries, not just representational and subject to interpretation (cf. Bechky, 2003a). As such, we join studies paying attention to the materiality of boundary work which includes other organizational artifacts beyond boundary objects (Barrett et al., 2012; Lindberg, Walter, & Raviola, 2017), such as how the materiality of space is constitutive of jurisdictional boundary reconfigurations and how artifacts such as 3D modelling enact group status and legitimacy, respectively. Second, we emphasize boundary work practices that are understudied in the boundary work literature, such as the importance of knowledge expertise and knowledge devaluing practices, which were key in relationally reconfiguring boundary relations between different groups when organizing for the innovation of 3DP. We define such knowledge expertise and devaluing practices as the tactics occupational groups engage in by invoking their unique occupational expertise to reconfigure boundaries and improve their status in innovation work.

The rest of the paper is organized as follows. In the next section, we review the jurisdictional boundaries literature, followed by the literature focusing on how technological artifacts can transform work practices and reconfigure boundaries. We then present our research methods and setting, followed by our analysis and discussion. We conclude by highlighting the contributions of our study and their implications for research on (boundary) work, occupations and technological change.

THEORETICAL BACKGROUND

Occupations and Jurisdictional Boundaries

Jurisdictional boundaries among specialized workers with localized knowledge and goals are prominent in organizations (Abbott, 1995; Cyert & March, 1992; March & Simon, 1958). Managing this localized knowledge requires boundary-spanning mechanisms for decision making, coordinating activity and innovating (Carlile, 2004; Okhuysen & Bechky, 2009). In this process, occupations and professions actively compete with one another by making jurisdictional claims, which are consequential for occupational group boundaries of core work domains (Abbott, 1988).

A notable stream of literature examines micro-level jurisdictional contests in the workplace. The focus is on occupational boundary contests, where inter-occupational contestation illustrates jurisdictional claims of occupational members. For instance, Bechky (2003a) compares the knowledge, authority and legitimacy claims of three occupational groups – engineers, technicians, and assemblers, and how their use of artifacts consequentially strengthens these claims. She notes that "occupations fiercely guard their core task domains from potential incursions by competitors" (p.721). Kellogg et al., (2006) examine coordination between four different occupational groups at an online marketing solutions organization. They found that cross-occupational attempts to coordinate work on client projects were thwarted by conflicts over issues of jurisdictional control, identity, and accountability.

This stream of research demonstrates how occupational groups' division of task labor in terms of jurisdictional claims is consequential for their relative standing and for organizational outcomes, such as shifts in jurisdiction, status, power, legitimacy and resource allocation (Anteby et al., 2016). This stream of research can be summarized as studies of competitive boundary work (Langley et al. 2019), which foregrounds how agents construct, defend or extend boundaries to distinguish themselves from others. They do so to maximize their social position and status, obtain resources, and reproduce or contest existing power relationships.

Occupations, Technological Change and Cross-Boundary Collaboration

Parallel to the research stream above, there is an extensive literature that highlights how technological artifacts can transform work practices and reconfigure boundaries, exploring how the introduction of a new technology can challenge and change situated occupational roles (cf. Leonardi and Barley, 2010). For example, in his studies of radiologists and technicians, Barley (1986, 1990) finds that occupational roles shifted with the introduction of new medical

imaging technology. Similarly, Bailey et al., (2012) also demonstrate how new technology introductions may shift occupational roles. In healthcare, more specifically, previous work has explored how occupational groups perform distinction practices to obtain access to a newly implemented technology in order to maintain or strengthen their power and legitimacy (Burri, 2008). Distinction practices are those practices aimed at enhancing occupational status and prestige in innovation work.

More generally, studies have explored how boundary objects are used in knowledge sharing across professional and organizational boundaries (Bechky 2003b; Carlile 2002; Gal et al. 2008; Levina and Vaast 2005). For example, Carlile (2002) develops a pragmatic approach to knowledge and boundaries in innovation, by showing the role boundary objects play in representing, learning and transforming knowledge across syntactic, semantic and pragmatic boundaries. Although these studies have examined distinction practices and how boundaries are spanned, fewer studies have looked at how these boundaries are reconfigured over time with the introduction of new technologies, and with what consequences for occupational work. One such example is Barrett et al.'s (2012) study of the introduction of a robotic innovation in a pharmacy setting). They contribute by emphasizing the importance of examining multiple boundaries and show how multiple robotic materialities (both digital and mechanical) are entangled with the groups' status, control and autonomy, such that they reconfigure boundary relations between three different groups. They contribute by explaining how, why and with what (contradictory) consequences technological innovations can reconfigure multi-occupational boundary relations.

We build on these insights to provide further theoretical insights on the role of materiality in reconfiguring boundary relations. Our case contributes by showing how the materiality of space for each of the occupational groups and that of artifacts such as 3D modeling were constitutive of boundary reconfigurations.

Theoretical Framework

We adopt a practice lens for examining boundary work practices as enacted by different occupational groups with the introduction of 3DP in a hospital setting (Feldman & Orlikowski, 2011; Gieryn, 1983; Nicolini, 2012). Boundary work, that is, work that discursively and materially shifts or maintains conceptions of the boundaries between different groups (Gieryn,

1983), has been a key concept for organizational and social science research (Lamont & Molnár, 2002; Zietsma & Lawrence, 2010). By drawing on boundary work and a practice lens, we are able to examine how practices establish, obscure or dissolve distinctions between occupational groups, viewing boundaries as relational, dynamic, and in a state of becoming (Tsoukas & Chia, 2002).

For the purposes of this paper, we conceive practices as recurrent, materially mediated, and situated activities (Schatzki et al., 2005), organized as sociomaterial sayings and doings guided by practical concerns (Nicolini, 2012) that are consequential in producing and reproducing boundaries (Feldman & Orlikowski, 2011). In this way, we examine how situated, material boundary work practices are configuring, maintaining or extending jurisdictional boundaries. Our findings unpack how the materiality of artifacts and spaces is constitutive of the way occupations mobilize, maintain and expand their jurisdictional boundaries, and finally, emphasize boundary work practices that are understudied in the boundary work literature, such as the importance of knowledge expertise and knowledge claim devaluing tactics.

METHODOLOGY

Our study aims to extend theory (Locke, 2001) on how occupations enact boundary work practices when a new technology is implemented in an organization. We followed an inductive research design, starting from an interest in organizing 3DP practices across occupational boundaries, and remained open to emerging fieldwork insights. Informed by a practice lens (Feldman & Orlikowski, 2011; Nicolini, 2012) and a process research approach (Langley, 1999), we collected detailed longitudinal data on how different occupational groups enacted boundary work practices, by deploying ethnographic methods and by following key episodes of jurisdictional claims occurred and experienced between multiple occupational groups processualy (Garud, Berends, & Tuertscher, 2017; Langley, 2009).

Research Setting

We performed a field study in a UK, National Health Service (NHS) hospital, spanning five years. The health care sector is an important one to examine boundary work and reconfigurations, as hospitals increasingly adopt 3DP technologies, with considerable implications for reconfiguring care practices, jurisdictions, work roles and identities (Barley 1986; Barrett et al. 2012). Additionally, health care is an ideal setting for exploring boundary

work practices given the large number of occupational groups and their high degree of stratification (Abbott, 1988). Our study hospital supports and accelerates the development of innovative medical technologies with the aim of addressing unmet patient needs, while improving patient safety. 3DP was one such technology that was introduced to the hospital and required organizing across diverse occupational groups, such as biomedical engineering - comprised of mechanical engineering technicians, R&D clinical engineers, as well as radiologists, surgeons and technicians who work collaboratively to design, develop and implement innovations at a centralized services lab (3DLab). Table 1 summarizes the different occupational group roles, initial practices before 3DP and transformed practices after the implementation of 3DP.

---------- Insert Table 1 ----------

Data Collection

We have collected longitudinal data over five years. The first author was granted almost unfettered access to the hospital as an honorary researcher, and regularly interacted with R&D, technicians, surgeons, radiologists and managers, developing several close informants at the hospital. The honorary researcher role was a natural one to conduct participant observation because the first author was an accepted, yet temporary, member of the hospital. Our primary data sources include 'zooming in' on 3DP practices (Nicolini, 2009), ethnographic, non-participant observations (343 hours), detailed field notes (400 single spaced) of how 3DP projects were negotiated and transformed over time (Emerson, Fretz, & Shaw, 2011), in-depth, semi-structured interviews with participants from various hierarchical levels and occupational groups (55), informal, in-situ interviews that regularly occurred while observing work (90), and finally, archival data (20GB of project progress documents, emails, technical specifications and design files of 3D printed medical devices). We also focused on critical events such as jurisdictional claims and tensions as they emerged.

Data Analysis

We adopted a process research approach (Langley, 1999, 2009), tracking the flow of events and boundary work practice enactments over time. The analysis consisted of multiple readings

of the interview transcripts, field notes and documentation, the open coding of discursive and other practices, as well as issues related to everyday work. We employed a multitude of strategies for analyzing the data, such as narrative strategy (Langley, 1999; Pentland, 1999), zooming in on practices (Nicolini, 2009) and visualizing patterns across jurisdictional tension events (Langley, 1999). We then focused on writing extensive theoretical memos and case narratives on our emerging findings and compiled an event-history database in Atlas.Ti throughout the fieldwork (Poole, Ven, Dooley, & Holmes, 2000). By performing temporal bracketing (Langley, 1999) while constructing our narrative, we brought together jurisdictional events based on our interviews, field notes and archival data, and traced the enactment of boundary work practices for different occupational groups, structuring our narrative in six phases. Finally, we traced how jurisdictional boundaries were reconfigured with the introduction of 3DP and identified linkages and patterns between different types of events and practices which were consequential for boundary work.

FINDINGS

Figure 1 summarizes our main findings and processualy identifies key episodes and events throughout our fieldwork, structured in six phases. We analyze boundary work practices, moves and countermoves between different occupational groups, and how the materiality of spaces and artifacts are consequential for jurisdictional boundary reconfigurations over time.

----------Insert Figure 1----------

Phase 1: R&D Expands Jurisdictional Boundary vis-à-vis Technicians

Extending R&D Space: The gradual shift in the technicians' practice was associated with the introduction of the R&D occupational group in their workspace. According to a member of the R&D group, "the design room [located in the technician workshop] used to be [technicians'] office, and one day, the head of our group would come in and plainly announce 'you have to empty the room', R&D is coming in". Another interviewee reflected on the gradual re-appropriation of the technician workspace:

"In the past, a lot more manufacturing took place than currently, but now R&D took over. There's a lot more documentation involved … so it's really a struggle because R&D are heavily involved in the innovation process, they have a scientific framework of thinking, they critically ask questions about why they are doing things and they strategically use their time and resources, while mechanical engineering don't really understand the documentation R&D go through" (Field notes, Medical Devices Evaluator, July 1st, 2016).

R&D Knowledge Expertise Extends Group Legitimacy: The documentation mentioned in the quote above refers to the quality system assurance necessary to meet appropriate medical devices legislation when 3DP medical devices. This issue was very important to the R&D group, as one of their core activities is risk managing, through the technical documenting of the devices they design and/or 3DP. They continuously spoke of the importance of the technical file documenting practice for risk management and for regulatory compliance. They emphasized that going through this process minimizes the chances of something going wrong. As the technicians' occupational group did not have the background or skills to go through the required technical documentation, their manufacturing projects were gradually taken over by the R&D occupational group, who used their knowledge expertise of technical documentation to extend their legitimacy vis-a-vis the technicians. They did so by claiming expert knowledge to justify their status in the process of innovation, hence convincing others that their approach was the legitimate one.

R&D Gradually Extend Task Boundaries through 3DP: Additionally, the R&D group's vision was to embed technology innovation at the heart of healthcare delivery, through their unique position as a bridge between front-line clinicians, patients and industry. They added value by rapidly prototyping medical device concepts in collaboration with clinicians, using design thinking principles and tools such as 3D modeling software. Their innovating practice, which used 3DP technologies, enabled them to gradually take over the technicians' tasks in the past years, such as collaborating with clinicians on crafting medical devices. In sum, R&D progressively expanded their jurisdictional boundaries vis-à-vis the technicians. First, they extended their resourcing space, enhanced their legitimacy using technical documentation knowledge expertise and then expanded their task boundaries through designing and innovating practices, including activities such as rapid prototyping and quality assurance documenting. At the same time, however, they were not the only occupational group using

3DP in the hospital. Other groups were eager to provide a centralized 3DP service to the hospital.

Phase 2: 3DLab Established Independently of other Departments

Establishing Task Boundaries and Space Jurisdiction: Centralizing the 3DLab away from any specific hospital department at a 'neutral place' was key, as the place where the 3D printers would be physically located played a crucial role in the process of innovation. There was debate for where to place the 3D printers, with options for centralizing the lab as a hospital wide service or departmentalizing the printers at discipline-specific departments (e.g. Craniomaxillofacial surgery). The radiologist who secured funding described the situation:

"Surgeons are engaging in empire building… presented with the opportunity, they will use any funding available to them to purchase a 3D printer solely for their own use with little regard about the rest of the hospital […] departmentalizing the 3DP service is wasteful and duplicating resources, a process prone to politics".

However, the radiologist who initially drafted the 3DLab plan, convinced the surgeons to locate the printers away from their specific disciplinary functions. According to the radiologist, "radiology is the nerve system… in order to take away political tensions, it is useful to find a neutral ground for the 3DLab which is run by technicians and radiologists, rather than specific surgeons/disciplines". As such, they located the 3D printers at a 'neutral place', as they called it, that is, "a place where no hospital division, surgical specialty or departmental politics would influence the use of 3DP". Additionally, the centralized 3DLab was equipped to cross-charge medical specialties for services both within and outside the hospital. As the head of the 3DLab explains:

"We already run as a cost recovery service, where we charge for everything that we do. We already have mechanisms for internal cross-charging within the organization but also invoicing other organizations, this is one of the reasons the service came to us".

By establishing the 3DLab as a centralized hospital service offering anatomical models to surgeons, the group of radiologists and technicians established their task boundary of 3DP anatomical modelling work in the hospital vis-à-vis the R&D group.

R&D Expulsion Work and Knowledge Devaluating: Although 3DLab grounded their task jurisdiction over anatomical modelling services offered to surgeons within the hospital, the R&D group often noted that their anatomical modeling practice was illegitimate and lacking in accountability. They referred to 3DLab as "medical photography", as they did not think their anatomical modeling practice was using the appropriate governance to assure quality of the 3D printed models served to surgeons. As one member of the R&D group noted:

"To provide quality assurance on any medical device, there has to be the appropriate traceability of material, storing of data and the technical file orientation, work instructions for thresholding and CT Scans with which the medical devices are designed… they do not use the appropriate quality assurance processes and workflow"(Medical Engineer, April 2016).

This was corroborated through our observations. During a meeting between managing directors of the hospital, the inter-occupational jurisdictional tension was highlighted:

Innovation Managing Director: What do you think is different between what you guys are doing?

R&D group member: Fundamentally, they [3DLab] do anatomical models for surgery planning, which is an issue because they recognize there needs to be a quality assurance structure around that, which they're being very slow at implementing, but we are hoping to support – basically if they just adopt our quality system we can bring them into ours, so they'll be under ISO certification. It's the same with all of the situations, we don't want to be a hurdle, and the trouble is that we are the regulatory gatekeepers… we are seen as the negative people.

Although the R&D group criticized 3DLab for their lack of accountability and frequently commented that the 3DLab technician did not have the appropriate level of seniority and skills to deal with 3D printed medical devices, they had a solution. They suggested 3DLab could use the R&D quality assurance system (ISO certification) to safeguard the hospital in case something went wrong with 3D printed anatomical models. In so doing, however, they were challenging the jurisdictional boundary of the 3DLab by devaluating their knowledge claims to 3DP, in an attempt to further extend their own task boundary through their technical documenting activities.

Phase 3: Inter-Jurisdictional Tensions between R&D and Technicians

Soon after the commencement of the study, we became aware of inter-occupational tensions between R&D and the mechanical engineer technicians when using 3DP. We unpack these jurisdictional contestations by paying attention to the jurisdictional claims of the occupational members and their consequences for boundary relations. Below, we present composite vignettes which are crafted from various data sources and by weaving our findings together (Jarzabkowski, Bednarek, & Lê, 2014).

Inter-Jurisdictional Tensions between R&D and Technician Groups – Vignette 1: *A new 3D printing project opportunity arrived at the hospital, an order for 3D printing fifty mobile phone cases that would provide additional mobile phone battery for a departmental trial study, with the aim of improving interactions with patients. The project was first delegated to the technicians, who attempted to manually machine the phone cases using traditional drilling and computer numerical control machines, but eventually failed to produce the cases. R&D group members were skeptical about the approach adopted by the technicians affiliated with mechanical engineering. They gathered in the R&D room and had a vibrant discussion about the technicians. Andrew, a clinical scientist with the R&D group, commented that "manually machining fifty mobile phone cases as per specification will take ages for the technicians, although they can do very finessed machining using 2D drawings, it is not the way we engineer in the 21st century […] yes, you can manually mill bits of plastic but you are probably talking about 2-3 days of work […] in order to speed the process of delivering design, we use 3D modelling in 3-4 hours and 3D print it or outsource the 3D printing, whilst you are getting on to the next project, and the cost would be a third of our hourly rate, so it's a no brainer really".*

Vignette 1 Analysis - R&D Further Extends Jurisdictional Boundary through 3DP Practices: As the vignette above demonstrates, the materiality of the artifacts each of the occupational groups used in their practices enacted jurisdictional tensions over the 3DP of the mobile cases project. The technician group used 2D drawings and operated traditional machining tools that require craftmanship and manual precision, whereas R&D used 3D modeling techniques to 3D print medical devices de novo, hence saving time and costs. 3D modeling and printing were used as representations of legitimacy and authority (Bechky, 2003a) to strengthen the jurisdictional claims of the R&D group. As such, the R&D practice

of innovating with 3D modelling and 3DP practices were consequential for the boundary relations between the two groups. It becomes clear from the ethnographic data in this vignette that the occupational groups of R&D and mechanical engineering were engaging in competitive boundary work, or working for boundaries (Langley et al., 2019). For example, as examined in phase 1, by extending their space of work, the R&D contested the tasks that technicians were engaging in and gradually claimed them for their own. To do so, they used knowledge expertise practices such as ISO certified documentation processes for quality assurance that they were unique to them. 3DP was integral to this process. Consequently, the technicians attempted to defend their boundaries over 3DP by taking on this new 3DP project of machining the medical devices. However, it became clear that their practices were not suitable for the timeframe expected and did not provide the necessary cost savings that 3DP could provide. At the end of this jurisdictional tension, the manager of biomedical engineering decided to remove the technician group from the 3DP process, and R&D took over their projects completely. The tension further demoted the technicians' status at the hospital and left them emotionally frustrated. As expected in competitive boundary work, the technician group attempted to defend their artifacts and task boundaries, which we explore in vignette 2 below.

Inter-Jurisdictional Tensions between R&D and Technician Groups – Vignette 2 (Technicians defend their artifacts and task boundaries): *Three months after the first 3DP tension outlined in vignette 1 above, another inter-jurisdictional tension occurred at the hospital. The R&D occupational group prepared an innovation project brief to gather investment and renovate the existing mechanical workshop where technicians performed their repairing practices, into a 3DP innovation hub. As they phrased it, the workshop had some "outdated and redundant kit" that could be removed, providing space for rapid prototyping facilities, quality-controlled manufacturing areas and meeting spaces. The materiality of the mechanical workshop included an array of milling, drilling and computer numerical control machines, along with trolleys and other medical equipment for repair. In other words, R&D envisioned a space for "inspiring innovation through building a creative and safe environment for design, prototyping and manufacture of medical technology, using 3DP". This was an attempt to further reconfigure their jurisdictional boundaries by proposing a reconfiguration of the materiality of the workshop space and a set of new innovating practices. However, their proposal backfired with unintended consequences, as the technician group actively resisted their proposal to defend their jurisdictional boundaries. The head of the technician group explained in their circulated email that "we've got to maintain some machinery for repairs, we do a lot of bed, scale and chair repairs… the word 'renovation' seems wholly inappropriate considering the small amount of space that may realistically become available, if current maintenance is to continue. Much more discussion is required to achieve a more balanced and prudent document to meet the needs*

of all". This view, however, was not shared by the R&D group. Indeed, as the head of the group shared with us, "using the limited space we have for bed maintenance is lacking in aspiration and vision… I would say get rid of the beds all together, we can receive £7m of funding from [innovation grants trust], so we must not let this get in our way".

Vignette 2 Analysis - Artifacts Enacting Legitimacy and Status: Vignette 2 highlights the discursive practice tensions between the R&D and technician groups, which eventually led to the abandonment of the space renovation project. Similar to Bechky's (2003a) findings that artifacts can be useful jurisdictional tools, the machinery of milling, drilling and computer numerical control machines were representations of legitimacy, signifying the value of the technician occupational group and used to make judgements on occupational skill and worth, as well as to reinforce occupational status. The technician repairing practice, enacted through these material artifacts, was threatened by the renovation proposal. In particular, the R&D group's proposition to remove their artifacts led the technician group to resist fiercely, defend their task boundary enacted by their practice of repairing and managing equipment, and eventually block the 3DP innovation hub proposal. In short, if the technician group had accepted the R&D proposition, they feared they would become redundant. This is due to the fact that their jurisdictional tools of milling, drilling were the only machinery they knew how to operate with. Hence, their removal would be consequential for their standing and their very existence in the hospital.

Phase 4: Neurosurgeons Bypass 3DLab Services and Collaborate with R&D to Design Cranial Plates

We observed additional boundary reconfigurations between the R&D group and the 3DLab in phase 4. The neurosurgeons thought 3DLab did not have the appropriate accountability processes and knowledge expertise to collaborate with them for 3DP cranial plates, nor did they have a metal 3D printer in situ to print the plates using titanium metal. The R&D group were keen to collaborate with the neurosurgeons to ensure the appropriate regulatory procedures were met. One R&D group member explained that "[we] like to keep the surgeons away from direct contact with 3DP", while another member explained this more thoroughly:

"A lot of the drive for 3D printing being brought into the hospital comes from surgeons. Whereas, we, one of our roles is to regulate medical classes within the hospital, so we get a little

bit… officious. You know, it really is important that people don't just make stuff alone and it is done through a robust design process"(Head of R&D Group, November 2016).

As a result, the 3DLab anatomical modelling practices were deemed inadequate for the cranial plates project. Through their collaborative activities with neurosurgeons, the R&D occupational group expanded their jurisdictional boundaries vis-à-vis the 3DLab, by extending their task boundaries of 3D modelling cranial plates for direct use in surgical practice. Over time, the 3DLab entered into financial difficulties meeting their projected model use as forecasted by their funding proposal, and they were struggling to keep the in-house 3DLab service running.

Phase 5: 3DLab Collaborates Closely with R&D to Expand their 3DP Services

In the face of 3DLab financial difficulty, the hospital management drafted a commercial plan to exploit opportunities for the provision of 3DP services outside the hospital, in February 2017. To make this happen, a closer collaboration between 3DLab, R&D and the technicians' occupational groups was deemed essential, as 3DLab had to work with R&D's quality assurance processes to supply to the external healthcare market. The radiologist at 3DLab explained:

"The majority of our [anatomical] models are used for surgical planning. One of the things that [the R&D group] is going to do for us is, obviously in this department we don't have a quality system, R&D are able to validate the work that we do"

R&D Suggesting Task Boundaries: In the following months, 3DLab and R&D intensified their collaboration for both designing and 3DP cranial plates, as well as developing external 3DP services for other hospitals. It became apparent to the groups that 3DLab was not doing well financially, as the surgeons were not using their 3DP services as much as they had proposed. R&D drafted an approved process workflow for 3DLab, based on quality system documentation, with the aim of ensuring appropriate governance for 3DP. Specifically, they drafted accountability mechanisms (reporting of all 3D printed items in a quality assurance software tool) and setting up responsibilities and roles. With the decision flow process, the R&D group attempted to define the task boundaries for the collaboration. They proposed that the head of biomedical engineering would be responsible for overseeing the quality

management system, while the head of the 3DLab would be responsible for manufacturing and delivering 3D printed medical devices.

Despite the closer collaboration between the different occupational groups, the financial troubles of the 3DLab was a key occasion for the R&D group to reengage in boundary work practices of drafting tasks for the collaborating, thus attempting to reconfigure their boundary relations. We elaborate on this in phase six below.

Phase 6: Further Jurisdictional Conflict between R&D and 3DLab Occupational Groups

In July 2017, the funding body of 3DLab had agreed to extend their funding under the conditions that R&D will be leading the lab and that the technician they employed would be subsumed under R&D. The managing director of 3DLab's funding body thought that the basement location for 3DLab was not the right place for 3DP. The head of the funding body explained that "I am not ready [for the 3DLab] to remain in the basement at all […] I think it'd be a good thing if it moved out of the basement". The main concerns surrounded the lack of the group's resilience and concerns about governance, that is, whether the 3D printed models qualify as medical devices, in which case, should be governed under a quality management framework for in-house manufacturing. R&D had the governance expertise and so the managing director wanted the 3DLab to be subsumed under R&D leadership, for medical device safety assurance. In their words:

"I think I'm entitled to express an opinion here… I think the 3DLab technician and the whole service should move to R&D, I don't think the 3DLab is the right place for it. The only complication with that is R&D do not have billing mechanisms for 3DP. So, then you need some sort of collaboration, where the 'retail' end if you like is managed by 3DLab and everything else is done by R&D".

As seen in the quote above, the arrangement envisioned an intensified collaboration between the occupational groups of R&D and 3DLab; R&D would be running the 3DLab service, while the 3DLab would take care of billing and cross charging the different hospital departments, as it was organized on a cost-recovery basis. Finally, the funding body director thought that 3D modelling practice of the technician at 3DLab was similar to the supervised and regulated practice of radiotherapy professionals and was thus important that the technician had proper supervision and clinical governance under R&D leadership. However, the above propositions

brought about ambiguity and tension over the task boundaries of 3DP work. The head of the 3DLab resisted the proposition to subsume the task area of 3DLab under the leadership of the R&D group, and explicitly mentioned they would resign as head of 3DLab.

DISCUSSION

Our study sought to address the research question of how occupations engage in competitive boundary work practices with the introduction of a new digital innovation at the workplace - 3DP in our case. Our longitudinal findings provide granularity as to the different boundary work practices four occupational groups enacted, and documents how inter-jurisdictional group boundaries were relationally reconfigured through such practices as extending task jurisdictions, expulsion work and knowledge devaluating, as well as using artifacts to enact legitimacy and status. For example, we find that R&D occupational group used their knowledge expertise of quality assurance significantly at different phases of the 3DP introduction and with different occupational, which, in conjunction to extending their work space and the use of 3DP artifacts (e.g. 3D modeling technologies and rapid prototyping), expanded their jurisdictional boundaries vis-à-vis the technicians and 3DLab by improving their legitimacy and status, marginalizing the technicians and shifting their practices to repairing equipment, eventually leading them to fiercely defend their task boundaries in phase 3, when R&D proposed a space renovation. In contrast to other jurisdictional boundary studies which place an emphasis on adversarial interactions and natural tensions, we find that R&D used their collaboration with other groups, such as the neurosurgeons, to further extend their own jurisdictional boundaries. Below we elaborate on the significance of our findings and discuss implications for different literatures.

Implications for Work and Occupations

The literature on occupational jurisdictions has investigated how occupational groups defend and maintain their boundaries at the workplace (Bechky, 2003a; Truelove & Kellogg, 2016), as well as how jurisdictional boundaries shift with the introduction of new technologies (Barley, 1986; Barrett et al., 2012). Key findings demonstrate that occupational groups may resist collaborating when their jurisdictional boundaries are under threat in light of organizational change (Truelove & Kellogg, 2016), draw on their knowledge and expertise to

establish and maintain authority over which tasks to perform (Abbott, 1988; Anteby et al., 2016) and how the use of new technologies by multiple occupational groups can reconfigure boundary relations with implications for work practices, roles and status (Barrett et al., 2012). Our paper builds on these insights and contributes by demonstrating how technology, in our case medical 3DP, reconfigures jurisdictional boundaries between multiple occupational groups at the workplace.

We extend the predominant focus on dyadic tensions between occupational groups in the literature (Bechky, 2003a). Our findings show how cooperative interactions and collaborative relations develop between occupations when a new technology is introduced (Carlile, 2004; Kellogg et al., 2006; Levina & Vaast, 2005). We show, however, that even when jurisdictional conflict seems to have subsided and groups seek to closely collaborate (such as in phase 5), R&D members used this opportunity to further engage in boundary work with the aim of extending their task boundaries vis-à-vis the 3DLab, leading to further jurisdictional claims and boundary reconfigurations in phase 6. Hence, although generative relations between occupations may develop, as is indeed necessary for innovating with a multidisciplinary technology such as 3DP, we demonstrate that occupations are actively engaging in ongoing boundary work that may lead to further jurisdictional tensions (cf. Anteby et al., 2016).

Implications for Occupations, Technological Change and Boundaries

Another stream of occupations literature investigates the "inertial" forces guiding occupations, for instance, by emphasizing how a new occupational group may strive for establishing legitimacy through highlighting values of appropriate practice conduct. For example, Fayard et al., (2016) examine how organizations enact epistemic stances to evaluate new IT-enabled practices, which are rooted in the larger organizational and professional fields of the organizations they studied, hence providing insights on *why and how actors* enact practices the way they do. Additionally, Nelson and Irwin (2014) examine the role of occupational identity as a lens for shaping responses to technology, and how the occupational group of librarians shaped Internet search based on their identity. Truelove and Kellogg (2016) focus on the heterogeneity within occupational groups and its congruence with occupation (radical) or organization (moderate) values. In our study, we observed similar 'inertial' dynamics, for instance, when R&D and 3DLab members enrolled 3DP in their innovating practice and actively configured and extended their task boundaries over time, as they drew on their

scientific framework of thinking, quality assurance and radiological expertise respectively.

However, this stream of literature downplays the role of materiality in these inertial forces. There seems to be a tendency towards favoring voluntaristic accounts of construction of shaping (Leonardi & Barley, 2010), at the expense of how the materiality of artifacts, digital representations and space matter for boundary reconfigurations. Building on recent insights on the role of materiality in boundaries (Barrett et al., 2012; Jonsson, Holmström, & Lyytinen, 2009; Nyberg, 2009), our study demonstrates how the materiality of artifacts and space is consequential for ensuing jurisdictional conflicts and boundary reconfigurations, not just representational and subject to interpretation (Bechky, 2003a). For example, the extension of the work space of R&D at the expense of technicians and the knowledge expertise of using the technical file orientation, were integral to the boundary extensions of the R&D group in phase 1. Additionally, the 3D modeling software and 3DP artifacts further strengthened the legitimacy and status of R&D when a 3DP innovation opportunity arose, as opposed to the use of 2D modeling and mill/lathe artifacts in the case of technicians, hence materially excluding the technician occupational group from the 3DP process in phase 3. Therefore, our empirical findings support calls for a sociomaterial perspective on work and organizing (Leonardi & Barley, 2010; Orlikowski, 2010), especially in relation to occupations. This presents an opportunity, going forward, for unpacking how the materiality of artifacts and spaces is constitutive of the way occupations mobilize, maintain and expand their boundaries (Langley et al., 2019).

Finally, the boundary work literature has investigated the strategies occupational groups employ in their attempts to establish, defend or contest professional (Bucher, Chreim, Langley, & Reay, 2016; Burri, 2008), disciplinary boundaries (Lindberg et al., 2017) and status (Apesoa-Varano, 2013) by protecting their autonomy, prestige and control of resources (Abbott, 1988; Gieryn, 1983). Recent work demonstrates the importance of discursive framing strategies that are influenced by occupational field positions based on status and centrality (Bucher et al., 2016), how technologies can challenge professional expertise and identity (Burri, 2008), and finally, how boundary work is a dynamic, material and iterative process constantly in the making (Lindberg et al., 2017). Our findings corroborate the dynamism of boundary work as a material, ongoing process, where boundaries are not given a priori, but rather enacted in practices that include material arrangements and artifacts, that can nevertheless change in meaning and use over time. However, we find that the role of knowledge expertise practices

and wider material arrangements such as the materiality of space are understudied in boundary work. For example, in our study, establishing and expanding resourcing spaces was an important boundary work practice for either expanding task jurisdiction (in the case of R&D vis-à-vis the technicians in phase 1), or for establishing a new work domain (as in the case of the 3DLab and 3DP anatomical modeling practice, in phase 2).

We identify and extend previous research on boundary work practices, by identifying practices (e.g knowledge devaluing, knowledge expertise practices) or exceptional events, processually, that exemplify the role of wider materiality and artifacts in the process, through conflict and contradictions. Even though previous literature focuses either on one, or the other, focusing on both can be seen as a strength of this study. At the same time, however, as Langley et al., (2019) argue, the degree of purposefulness or reflexivity may vary considerably in boundary work studies. For example, there is a clear difference between the highly intentional and planned activities of the physician entrepreneurs in Mørk et al.'s (2012) study of the creation of a boundary organization and the everyday pre-reflexive boundary interactions nurses and doctors undertake in their daily work. In this way, boundary work is also a thoroughly mundane performance, carried out in the background and pre-reflexively without being foregrounded and thematized in terms of long-term calculation. Thus, competitive boundary work and collaborative boundary work should be studied together and explicitly embedded into future research designs.

In other words, competitive and collaborative boundary work are two forms of boundary work that constitute different facets of the same phenomenon, that is, jurisdictional boundaries are enacted through both types of work. Hence, this provides an opportunity for future research to resolve this dichotomy by further embracing relational and processual views of agency that do not contrast mundane routine activity and purposefulness or reflexivity, as is common in the individualist and calculative conceptions of agency that prevail in management studies (Langley et al., 2019). Human agency is a practical and situated engagement with different materialites (cf. Barrett et al., 2012), and always encompasses elements of repetition, projection toward the future, re-interpretation of the past, and practical evaluation of possible immediate and future consequences (Emirbayer and Mische 1998).

CONCLUSION

We studied how four occupational groups enacted boundary work practices to extend their jurisdictional boundaries by improving their status, authority and legitimacy when a new

technology created challenges for collaboration in the multi-occupational context of medical 3DP in health care. By adopting a practice lens and using boundary work as an analytical tool, we examine how situated, material boundary work practices are configuring, maintaining, and extending boundary relations through jurisdictional claims. We highlight the role of knowledge expertise and wider material arrangements such as space as important aspects in boundary work. Our findings are limited to the extent that we only examined a specific innovation in a particular organizational context, but we believe our insights are valuable and generative. Further research is needed to verify and elaborate on them, to examine how jurisdictional boundaries are reconfigured in other contexts and with other digital innovations.

TABLE 1:
OCCUPATIONAL GROUPS AND PRACTICES AT UK HOSPITAL

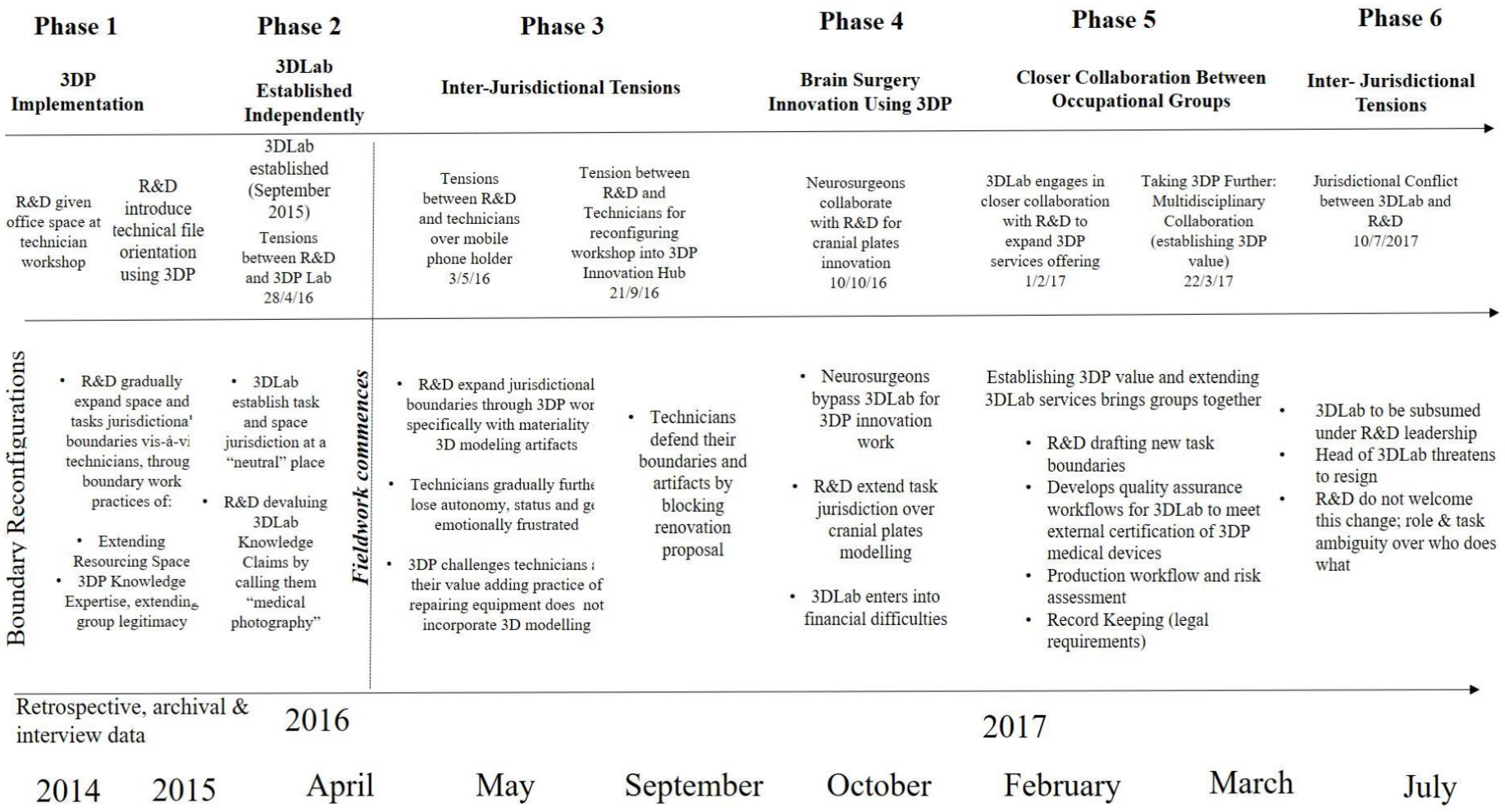
Occupational Group	Initial Practices	Transformed Practices	Work Activities	Empirical Material
Mechanical Engineering Technicians: Technical experts with significant knowledge and experience in manufacturing (hand crafting) medical devices using such artifacts as 2D modelling, lathes, drilling machines and computer numerical control machines	• Before the introduction of 3DP modelling practices at the Biomedical Engineering department, they collaborated with clinicians across the hospital to manufacture medical devices upon request. • Their occupational group membership was that of mechanical engineering, which provides skilled instrument makers, trained through on-the-job apprenticeship.	*Repairing and Managing Medical Equipment* After the introduction 3D modelling by the R&D group, their practices gradually shifted to repairing equipment	*Repairing Medical Devices* *Generating Spare Equipment Orders*	*"we've taken on contracts regarding the overhaul of hospital beds, scales, hoists, chairs, couches"* Interview, Head of Technicians' Group *"On a yearly basis, we check all our equipment out and then if spares are needed, we have to source those and generate orders"* Interview, Senior Mechanical Engineer
R&D Clinical Engineers: Research and development experts with significant knowledge in embedding technological innovations at the heart of healthcare delivery. They have significant expertise with medical devices regulation, governance, and risk managing, using such artifacts as 3D modelling, rapid	Technical file documenting; the R&D group enacted the practice of collecting all the appropriate documentation that adhere to standards and medical devices legislation.	*Designing and Innovating* After the implementation of technical file documenting, they shifted their practices towards designing and innovating with 3DP.	*Project Briefing* *Designing and Rapid Prototyping of Medical Devices* *Technical File Documenting for 3DP*	*"We create project briefs for 3DP projects, their market potential and design 3D models for review, which guide our practices"* Interview, R&D Clinical Scientist *"At the core of our work is medical device design, applying rigorous scientific principles to approach healthcare problems"* Interview, Medical Engineer *"we do technical file evaluation for medical devices... going through this process minimizes the chances of something going wrong"* Fieldnotes, Medical Evaluation Specialist, March 2016

prototyping and technical documentation. The group was comprised of clinical engineers and registered clinical scientists, who hold a degree in life sciences, complete a 3-year NHS Healthcare Scientist Training Program (STP) and are registered with a national body for licensed health-care professionals in the UK, the Health and Care Professions Council (HCPC).	• As the department of biomedical engineering has to CE-mark 3D printed devices (European conformity standard), their ISO-13485 certification makes sure they meet the appropriate medical devices directive legislation		*Collaborating with diverse occupational and professional groups*	*"we have a multidisciplinary team to sign off [3D printed designs and devices between ourselves, the clinicians and the whole surgical team [...] we have the scan, we extract using the software [shows the toolkit and examples on the screen], we do the design. We then submit the design in a 3D-PDF, so they can view. Then it gets sign off from the whole group and goes out to additive manufacture. That is the way we have got checks and balances from all sides"* Fieldnotes, Medical Engineer, November 2016
3DLab: A multidisciplinary group bringing together surgeons, radiologists, and technicians for using 3DP. They secured funds to establish an in-house, centralized 3D services lab (3DLab), with the aim of enhancing patient care.	• Utilized 3D images of human body structures to create 3D models of patients' anatomy and deliver anatomical modelling services to different specialty surgeons. • They set up a digital infrastructure; imaging datasets were obtained from radiology in their raw format (DICOM data) and were imported into specialist software packages.	*Anatomical Modelling* Enacted the practice of anatomical modelling to facilitate surgical planning. This practice was the core 3DLab practice for the duration of our fieldwork. The structure was identified and turned from sliced imaging into a 3D structure, by engaging in segmenting practices, which could be rotated and edited on screen. The software then produced a stereolithographic (stl.) file, required to	*Segmenting CT or MR images* *Consulting human anatomy books*	*[the lab technician] loads the 3D model of the patient skull on his large iMac screen, with what seemed to be a fractured mandible, taken directly from CT scans and modelled instantly. After a period of deliberation, the technician comments that "now I need to remove the parts they [referring to maxillofacial surgeon] are interested in (showing the green areas of the CT scan layers of the model as the bone).* Fieldnotes, January 2017 *"I consult the books all the time. It is very challenging, but usually the end user (surgeon etc.) will sit here with me to help me do the model and explain what they want"* Fieldnotes, January 2017

		communicate with the 3D printer software. Once modelled using CAD software, further adjustments could be made in terms of coloring and sizing, and the finished file was sent to the 3D printer. We summarize the anatomical modelling practice of the 3DLab in table 3.		
Neurosurgeons: Identified opportunity to use 3DP for craniotomy surgical procedure.	• Designed patient-specific, implantable cranial plates. • A cranial plate is a prosthesis to replace a portion of the skull that has been removed through craniotomy. This is undertaken to treat brain injury and manage swelling in the brain.	Neurosurgeons bypassed the 3DLab and directly collaborated with the R&D occupational group to design the patient-specific cranial plates. Outsourced the titanium-metal 3D printing to an external organization.	*Collaborating with R&D Occupational Group*	*"there is a patient waiting list, at least 50 people with a hole in the head…we are using a proper 3DP with binder and glue to 3D print these plates"* Interview, Neurosurgeon *"The R&D group are sourcing the 3D software, providing the regulatory expertise and emotional support in the process of innovation"* Interview, Neurosurgery Fellow

FIGURE 1

DISCREPANT EVENTS TIMELINE, BOUNDARY WORK AND RECONFIGURATION



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Conclusion

The final chapter of this dissertation directly responds to the overarching question outlined in the introduction. To do so, the chapter summarizes the contributions of each paper, in relation to the perpetual challenges of innovation, specifically in healthcare, as identified in the introduction. I then theorize the insights of all three papers taken together for the literature of digital innovation. I conclude with reflections and implications for future research.

This thesis has identified perpetual challenges to innovation in healthcare - a sector that is, globally, under pressure, and has set out to address them. Digital innovation has tremendous potential for transforming healthcare delivery, improving care quality, while reducing costs. One significant challenge in realizing these benefits is justifying digital technology investments in the first place, against the backdrop of a highly regulated healthcare field, which makes establishing the value of digital innovations extremely difficult.

Insights for the Overarching Research Question

The overarching research question in this thesis is *how can we address the ongoing challenges of organizing for digital innovation at different stages of the process, including the underexplored allocation stage, as well as the usage and appropriation stages?* At a broader level, to investigate this overarching question, I focused on three specific areas of the phenomenon (please see table 1 and figure 1 in the introduction). By utilizing the theoretical framework in the introduction, I conceptualize organizing for digital innovation as three interrelated challenges facing the healthcare sector at three different stages of the IS investment process. The first one being justifying and establishing value at the underexplored allocation stage, the second scaling digital innovations at the usage stage and finally, addressing occupational dynamics at the appropriation stage.

Overall, a first contribution of this thesis is to conceptualize organizing differently, at different stages of the digital innovation process. I explore this below.

Paper One: Justifying HIT investments. The first paper of the thesis was inspired by how practitioners justify health investments and their value, in practice. The paper's contribution is threefold. First, we devise a novel theoretical framework that conceptualizes value as performed through framing practices. This way, we contribute a performative perspective on the phenomenon of value and organizing, which is fluid and enacted in the doings of organizational actors (Feldman & Orlikowski, 2011). A performative framing practices

perspective contributes by theorizing how temporal orientations grounded in value seeking approaches (reactive or proactive) and time horizons (short or long term) are continually performing multiple aspects of HIT reputational value. Second, we contribute a process model of framing practices and reputational value in healthcare, which suggests a re-orientation of value, from being a singular, one-off outcome (as illustrated by the dominant literature on operational and financial notions of HIT value), to a process understanding of how value (in our case reputational value) may be mutable. That is, HIT reputational value as a dynamic, ongoing process, continually unfolding and constituted by ongoing reconfiguration. Finally, we identify the performative framing mechanisms through which practitioners were justifying HIT investments, as a way of responding to the perpetual challenge of justifying investments. In particular, we show how framing practices may lead to favorable reputational value being enacted for commissioners, regulators, and hospital staff, yet negative assessment of new clinical practices, such as from unplanned disruptions during IT implementation, can enact negative reputational value from the perspective of patients. This insight, coupled with our findings of the ongoing need for maintaining reputational value, suggest hospital organizations need to engage in continuous efforts for enacting aspects of the same value differently for different stakeholders. Finally, organizing is conceptualized as performative through framing practices that enact value, which is fluid and mutable.

Therefore, to address the first perennial innovation challenge of justifying and establishing the value of digital innovations, the thesis provides insights into *how* practitioners enact framing practices to do so.

Paper Two: Scaling Digital Innovation. Beyond justifying HIT investments at the allocation stage, another perpetual challenge in the healthcare sector is scaling up innovations across the hospital and wider sector. The second paper of the thesis was inspired by the scaling challenge, which also inductively emerged during the five-year long fieldwork. By examining the exemplary digital innovation of 3DP, this paper first contributes by demonstrating the continued importance of place with the digitization of innovation. In particular, the paper further refines how places are implicated in the digital innovation process. For example, the theoretical model of the paper goes beyond the view of place as a geographical locale and theorizes the constitutive role of resourcing strategies, materiality and location meaning, which taken together, explain how and why the digital innovation of 3DP failed to scale up in three different places. Second, the paper contributes to the scaling literature by showing that "scaling up" requires a fine-grained understanding of local spaces rather than simply "sizing up" across

different geographies. Through place dynamics such as place bending and framing, we go beyond the common expectation that scaling requires jumping from one geographical locale to another, while showing how scaling is a material process. Therefore, to address the perpetual challenge of scaling digital innovations, the thesis conceptualizes organizing as at the usage stage as through specific scaling practices that are consequential for organizing digital innovation successfully. Specifically, the thesis provides a fine-grained understanding as to how place dynamics are related to challenges associated with digital innovations in different places. Through place dynamics such as place bending, extending, and framing, we go beyond the common expectation that scaling be conceptualized as jumping and sizing up across different geographical locales, which makes scaling so challenging in the first place.

Paper Three: Reconfiguring Boundary Relations with Digital Innovation. The third paper examines the challenge of addressing the role of occupational dynamics in digital innovation. Here, the focus is the ongoing jurisdictional contestations between four groups. The paper contributes by unpacking how the materiality of artifacts and spaces is constitutive of the way occupations mobilize, maintain and expand their jurisdictional boundaries, not just representational and subject to interpretation (Bechky 2003), a key issue in the healthcare sector. As such, we join studies paying attention to the materiality of boundary work which includes other organizational artifacts beyond boundary objects (Barrett et al. 2012; Lindberg et al. 2017), such as how the materiality of space is constitutive of jurisdictional boundary reconfigurations and how artifacts such as 3D modelling enact group status and legitimacy, respectively. By responding to the call of Langley et al., (2019) for greater attention to materiality in boundary work going forward, the paper contributes by showing how technological artifacts together with physical spaces are constitutive of competitive boundary work. As such, we conceptualize organizing as enacted through specific competitive boundary work practices at the appropriation stage. Hence, to address the occupational challenges that are integral to appropriating digital innovations, the thesis proposes that we go beyond a conception of boundary objects as static devices for communication across preexisting boundaries, to showing how the wider materiality of spaces and artifacts is directly implicated in their constitution and negotiation.

Theorizing for Justifying and Implementing Digital Innovations

To gain a more nuanced understanding of how HIT investments are justified, how value is enacted in the digital age, the role of place in scaling digital innovations, as well as how

occupational groups are consequential for the implementation of such innovations, all three papers follow a practice-based perspective (Feldman and Orlikowski 2011; Nicolini 2012). This approach afforded the examination of digital innovation from a "bottom-up" perspective, that is, looking at the emerging, multifaceted, and often serendipitous nature of digital innovation.

Overarching Contribution 1: Extending the practice perspective for the allocation stage

This dissertation closely aligns with emerging studies that take a practice or sociomaterial perspective to examine digital innovations, such as robotics (Barrett et al. 2012) and value in the digital age (Barrett et al. 2016). The contribution of these studies to the digital innovation literature has been twofold. First, they have elucidated the importance of adopting a process approach connected to longitudinal field research designs, which demonstrates the temporally unfolding, emergent, dynamic process of digital innovation. Second, in line with calls for greater attention to materiality in organization studies (Leonardi and Barley 2008; Orlikowski 2007; Orlikowski and Scott 2008), these studies highlight the important role of materiality in digital innovation, specifically, how shedding light on how different materialities of digital innovations are performed in practice. This thesis joins these efforts in highlighting the importance of taking a process and/or practice perspective in examining varied digital innovation phenomena.

More specifically, however, previous work tends to focus on the implementation stage, by treating investments in digital technologies as "given", unitary and unchanging, with the primary emphasis placed on evaluating the consequences of these investments (cf. Salge et al., 2015). This thesis contributes an understanding of the underexplored resource allocation stage from a practice perspective. For example, *Paper One* contributes by demonstrating how the temporal orientation of the framing practices used for justifying digital technology investments matters for the consequent use of the innovations and their value. The paper provides an understanding of the dynamic way in which reputational value is performed through the ongoing process of justifying HIT investments, which is influenced by the temporal orientation of the framing practices used in each of the case studies, performing possibilities for restoring, enhancing or maintaining reputation. It is important to note, however, that from a practice perspective, the purpose of examining technology and innovation stages by sequentially combining them is an analytical distinction only; by definition, a simplified approximation of a decentralized digital innovation process accomplished emergently through diverse goals,

motives and practices (e.g. Nambisan et al., 2017). Nevertheless, there are generative insights from examining the allocation stage in helping academics and practitioners alike in understanding the temporally oriented justifying practices for establishing value in the digital age.

Overarching Contribution 2: Demonstrating the role of Places and Materiality in the Duality of Physical/Digital Innovations

The last few years have seen the proliferations of new places and spaces dedicated to work and collaboration, either physical, such as innovation labs or co-working spaces, and/or virtual (e.g. crowdsourcing communities, online communities), that have greatly affected innovation processes. However, we know relatively little about how these new places of work and innovation emerge and how they are nurtured, especially with digital innovations that bridge the physical and digital domains. In other words, the role of place in digital innovation remains nascent in theoretical and empirical work. This dissertation sheds some light on this question, in the context of healthcare. *Paper Two* demonstrates how and why places are consequential and still very important in scaling up digital innovations. Building on the emerging stream of research that examines how distinct geographical places associated in local practices, materialities and values necessarily shape and transform the trajectory of innovations over time (Oborn et al., 2019), *Paper Two* contributes by further refining how places are implicated in the digital innovation process. For example, our theoretical model goes beyond the view of place as a geographical locale and theorizes the constitutive role of resourcing strategies, materiality and location meaning, which taken together, explain *how* and *why* the digital innovation of 3DP failed to scale up and grow in three different places. *Paper Three* demonstrates the role of materiality during competitive boundary work (Langley et al. 2019), when implementing the digital innovation of 3DP. Our findings corroborate the dynamism of boundary work as a material, ongoing process, where boundaries are not given a priori, but rather enacted in practices that include material arrangements and artifacts, that can nevertheless change in meaning and use over time, with the introduction of the digital innovation of 3DP.

Boundary Conditions and Future Research Opportunities

I conclude this dissertation with the boundary conditions of the findings presented in this thesis, which provide interesting future research opportunities. Academic research on this domain can provide counter-intuitive insights, for example, by demonstrating the emergent nature of digital

innovation, the struggles that can ensue, as well as highlight unintended consequences. The dissertation, therefore, questions managerial attempts that view digital innovation as a panacea in alleviating healthcare costs and improving care quality. Even though digital innovation does hold considerable hope and promise, this thesis highlights the unintended consequences of implementing these innovations in practice. As *Papers Two* and *Three* demonstrate, scaling up of digital innovation can be particularly challenging, as occupational groups enact different place dynamics, such as bending, framing and jumping, which nevertheless can fail to scale the innovation across the hospital. At the same time, paying particular attention to the occupational dynamics and the role of materiality are fruitful avenues for future research.

A limitation of this thesis is that it was performed under certain limitations, which need to be discussed so as to consider the boundary conditions of the findings. Firstly, although the data collection for this thesis spans a period of five years, the first two years of data concerning the jurisdictional boundary work practices were collected retrospectively. This may bias the accounts I have crafted in papers two and three, as real-time observation was missing. However, I attempted to overcome this limitation by triangulating the information between multiple interviewees from diverse roles, occupational groups and interests, as well multiple sources (documentation). Secondly, my perceived affiliation with the R&D department at the field site hospital may have influenced my interactions with other occupational groups. Gaining access this way provided a natural role for me to conduct participant observation because I was seen as an accepted, yet temporary, member of the organization. Nevertheless, many interviewees from other occupational groups in the hospital were skeptical about my questions and observations.

The limitations above provide a boundary condition for the findings of this thesis, which is related to the setting in which 3DP was introduced. As previously discussed in papers two and three, healthcare is an exemplary setting to study competitive boundary work practices, due to the multiple practices of a plethora of diverse groups. Even though I would expect to see similarities in the boundary reconfigurations between groups in other professional settings, such as professional services, the generalizability of these findings to other settings would warrant further study. Indeed, this provides some fruitful avenues for future research.

First, this thesis has employed both comparative case study research methods, along with ethnographic, longitudinal methods at three different hospital sites. Future research can focus on an explicit comparative focus that can further illuminate the contingencies that may

influence the enactment of boundary work in similar settings (cf. (Langley et al. 2019). This can help us understand when and where it may be more consequential in positioning actors favorably against their competitors (competitive boundary work), in enabling collaboration (collaborative boundary work), as well as in in orientating patterns of collective action from the outside (configurational boundary work). This is especially the case with digital innovation, which requires heterogeneous efforts from different occupations and different organizations.

Second, another possibility for future research is to observe how surgical practices are reconfigured with the introduction of digital innovations at work, such as 3DP. For instance, even though negotiating access to the field site through the R&D department provided multiple opportunities, it made it increasingly difficult to obtain access and observe the surgical practices of using 3DP in practice, especially given the relatively slow spread of 3DP innovations across the hospital. Future research can more closely examine areas such as surgery and surgical planning practices, to gain a more granular understanding of how the emerging technology of 3DP is implemented in practice.

Finally, future research can further nuance digital innovation theory by examining innovations that bridge the physical and digital domains. Paper two suggests that place is an important material dimension that is often overlooked, and that place, being relational, can influence the materiality of digital technologies, particularly those which have integrated digital and physical components. For example, 3DP as an innovation that bridges the digital and physical domains, requires both digital modelling practices and physical 3D printers located in particular places to transform digital models into customized, tangible artifacts. Previous work has recognized the importance of digital and physical materiality in the process of organizing more generally (Faulkner and Runde 2009, Leonardi 2010), and for digital innovation more specifically (Barrett et al. 2012). Future research can build on Jones and Rose (2016), who distinguish between two distinct types of digital innovation: those that bridge the digital and physical domains, and those that operate solely in the digital domain. 3DP is an innovation that bridges the digital and physical domains, in that innovation occurs both in the software (e.g. digital modelling of objects) and physical domains (e.g. innovation in printing technique and materials). Hence, this thesis hopes to spark interest in scholars interested at the intersection of domains of organizing, work, technology and innovation, to study digital innovation in a sociomaterial manner and to take into account both the digital and physical domains.

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