The Digital Undertow:
How the Corollary Effects of Digital Transformation Affect Industry Standards

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Abstract

Scholarship on digital transformation has centered on how waves of digitalization have moved through industries, producing strategic changes within and across firms and enabling new forms of value creation. In this paper, we argue that different but no less important processes of digital transformation are generated by the undertow produced by these waves. This digital undertow, a corollary effect of waves of digitalization, profoundly influences how firms operate by transforming the industry standards that coordinate and regulate their core business activities. Using a genealogical approach, we draw on findings from a longitudinal field study in book publishing to theorize the tensions and processes that constitute the digital undertow. We explain that when waves of digitalization transform firms' core activities, they unwittingly affect how industry standards correspond with materializations of the phenomena they structure, thus influencing how standards perform in practice. A significant outcome of recent waves of digitalization in the book industry is the loss in correspondence between industry standards and novel digital materializations of the book. This is producing what we refer to as digital displacement, a process that is engendering an existential challenge to the capacity of standards to effectively coordinate and regulate industry operations in the digital age.

Digital transformation of organizational and societal life has grown in significance, forming a vital and ongoing area of contribution for information systems research (Hinings, Gegenhuber & Greenwood 2018; Majchrzak, Markus & Wareham 2016; Vial 2019; Yoo, Henfridsson & Lyytinen 2010b). Broadly understood as the process of using digital technologies to produce strategic organizational changes that alter forms of value creation (Besson & Rowe 2012; Vial 2019), digital transformations have resulted in profound shifts at both firm and industry levels. Research suggests that digital transformations arise as digital innovations move through multiple waves of digitalization (Yoo et al. 2010a) producing a range of generative outcomes. Studies of these digital transformations have examined new digital services and products (Leonardi, Bailey, Diniz, Sholler & Nardi 2016; Lusch & Nambisan 2015; Yoo et al. 2010b), innovative digital platforms and infrastructures (Hinings et al. 2018; Tilson, Lyytinen & Sørensen 2010), as well as novel digital business strategies (Adner, Puranam & Zhu 2019; Bharadwaj, El Sawy, Pavlou & Venkatraman 2013; Pagani 2013) and digital business models (Karimi & Walter 2015; Warner & Wäger 2019; Weill & Woerner 2015).

Much of the digital transformation scholarship has centered on value creation — the pronounced strategic shifts in processes, services, and products within and across firms (Boland, Lyytinen & Yoo 2007; Vial 2019; Warner & Wäger 2019; Yoo et al. 2010b). While such prominent changes in core business activities have understandably been the primary research focus, what has been overlooked are the less visible but no less significant emergent outcomes of digitalization that are transforming industry standards. As industry standards are key mechanisms that structure industry-wide activities, flows, and relations, their transformation has far-reaching implications for how effectively firms and industries operate. Our study thus sought to understand these critical albeit less prominent outcomes of digitalization, posing the research question: *how does digital transformation affect industry standards?*

Based on an extensive field study in the book industry that examined the long-standing book standard (the ISBN), we found that this industry standard has undergone substantial changes as a result of multiple digitalization efforts within the book industry. Drawing on a fine-grained process analysis, we argue that as waves of digitalization transform core business activities, they also necessarily and unwittingly transform

the standards that structure those phenomena. These latter transformations are a consequential corollary effect of digitalization efforts, flowing directly from them even though they are not their specific target.

Building on the metaphor of waves, we refer to the corollary effect of digitalization as the *digital undertow,* the processes of which transform industry standards. We develop a process model to convey a set of novel constructs that communicate the tensions and processes constituting the digital undertow. Drawing on our findings, we differentiate three distinct transformations of industry standards: developing, expanding, and displacing. Our further theorizing considers how different digitalization efforts affect the correspondence of industry standards with materializations of the phenomena they structure.

Our research makes a number of contributions to scholarship. First, we identify and explicate an unwitting digital transformation that has not been much studied to date — the transformation of industry standards arising from waves of digitalization. We note that prior literature has addressed the unintended consequences of technological change in terms of broad categories such as side effects (Hanseth, Jacucci, Grisot, & Aanestad, 2006; Scott 2000), drift (Berg 1997; Ciborra et al. 2000), emergence (Boudreau & Robey 2005; Orlikowski 1996), and complementarities (Brynjolfsson & Hitt 2000). Our grounded theorization of the digital undertow as a corollary effect of digital transformation adds to this extant analytical vocabulary by conceptualizing the distinctive unintended changes to industry standards that result from strategic digitalization efforts aimed at value creation.

Second, our findings enable us to contribute a detailed perspective on the relation between digital transformation and industry standards. While the standards literature has long examined the establishment, revision, contestation, and demise of industry standards (Busch 2011; Yates & Murphy 2019), what has not been explained is how and why different waves of digitalization affect industry standards. Our theorization relates industry standards to materializations of the phenomena they structure. We argue that industry standards work well when their rules and guidelines correspond with materializations of the phenomena they coordinate and regulate, and they stop working well when their rules and guidelines no longer correspond with materializations of these phenomena. The loss of correspondence of standards with novel digital materializations has become particularly acute in recent waves of digitalization, producing what we term digital displacement, a process which is eroding the

authority of industry standards to coordinate and regulate industry-wide activities, flows, and relations. As evident in our study, the process of digital displacement is deeply consequential as it undermines the capacity of standards to effectively structure how firms and industries operate in the digital age.

In the following, we discuss and build on existing research on digital transformation and standards, and then describe our research approach and methods. Our empirical findings center on successive waves of digitalization in the book industry and the consequential processes that are transforming the ISBN standard over time. We draw on these findings to theorize the relations between digitalization and industry standards, and then discuss the broader implications of our work for future research.

LITERATURE ON DIGITAL TRANSFORMATION AND STANDARDS

The work on digital transformation in the information systems (IS) field has been both extensive and wide-ranging, encompassing a range of views and conceptualizations among researchers (Besson & Rowe 2012; Riasanow, Setzke, Böhm, & Krcmar, 2019; Vial 2019) and practitioners (Warner & Wäger 2019). Much prior research is concerned with how firms use digital technologies to alter value creation processes in response to innovations in their industries. A few studies do examine broader societal and political implications of digital transformations that are evident, for example, in healthcare, financial inclusion, rural empowerment, and ethical, security, and privacy issues (Agarwal, Guodong, DesRoches & Jha 2010; Majchrzak et al. 2016). Given our interest in how digital transformations of firms' core activities affect the role and consequences of standards in practice, we found it useful to focus on three streams of literature: studies of strategic digital transformation, research on infrastructural digital transformation, and considerations of standards and digital transformation. We then build on key themes in these research streams to articulate the conceptual approach that informed our research study.

Strategic Digital Transformations

Focusing on the strategic aspects of digital transformation, this research stream examines how different kinds of digital innovations generate novel business models and value creation paths that produce substantial shifts in firms' core processes, services, and products (Nambisan, Lyytinen, Majchrzak & Song 2017; Yoo et al. 2010b). These digital innovations may be endogenous, arising from

firms purposefully crafting strategic initiatives to leverage the opportunities offered by digital

technologies, or they may be exogenous, arising from competitive threats within or beyond the industry

that trigger strategic responses from focal organizations (Vial 2019). Whether viewed as endogenous or

exogenous, the interest of this research stream is on how digital capabilities transform organizations'

value propositions through changes in business models and market dynamics, producing innovative

services and products, enhanced customer experiences, and improved firm performance (Bharadwaj et al.

2013; Karimi & Walter 2015; Nambisan, Wright & Feldman 2019; Warner & Wäger 2019).

In examining the transformative effects of digital innovation, a number of scholars make an important

distinction between *digitization* and *digitalization* (Tilson et al. 2010; Yoo et al. 2010a, 2010b). The

former is a technical process of "converting analog signals into a digital form" (Tilson et al. 2010, p. 725),

while the latter refers to "the transformation of socio-technical structures that were previously mediated

by non-digital artifacts or relationships into ones that are mediated by *digitized* artifacts and relationships"

(Yoo et al. 2010a, p. 5, emphasis in original). These scholars propose that digitalization proceeds in

successive "waves": early waves digitize analog content and processes by essentially "digitizing the cow

paths" of existing organizational structures (Tilson et al. 2010, p. 750), followed by more innovative

waves that facilitate decoupling and convergence across data, services, and devices that blur established

boundaries and enable new forms of service delivery, leading on to current waves of digitalization that

recombine modularized digital formats to generate novel products and services.

While the primary focus of this strategic research stream is on understanding how firms engage with

digital innovations to implement new ways of creating and capturing value, a few studies have looked

beyond firms to examine digital transformations of value networks and digital ecosystems involving

multiple partners, suppliers, and customers (El Sawy et al. 2010; Jha, Pinsonneault & Dubé 2016; Leong,

Pan, Newell & Cui 2016). For example, Boland et al.'s (2007) study of digital innovation in the AEC

(architecture, engineering, construction) industry highlights how first mover changes in architectural

design instigated important transformations within an architectural firm using a 3-D modeling tool. These

inspired new ways of working that cascaded across the industry as AEC partner firms adopted and

modified the tool to their interests, spawning multiple "wakes of innovation" (ibid) that overlapped and

intersected with each other to produce widespread digital transformation in core AEC activities and relations. This research has contributed valuable insights beyond the more common firm-centric perspectives, showing how digital transformation may emerge in multiple, diverse, and distributed ways across organizational networks (Boland et al. 2007).

Digital transformation in core business activities, whether at the firm or industry level, depends upon infrastructures to produce and sustain value creation. Of particular relevance to our study is the literature that considers the dynamic interplay of infrastructural digital transformation with standards, and we now turn to this research stream for its insights.

Infrastructural Digital Transformations

Infrastructures are "built networks that facilitate the flow of goods, people, or ideas and allow for their exchange over space" (Larkin 2013, p. 328). The digital infrastructure literature focuses on "the basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function" (Tilson et al. 2010, p. 748). The term *infrastructure* is intended to encompass "interconnected system collectives," moving the field away from studies of single-site IS (Henfridsson & Bygstad 2013). Tilson et al. (2010) argue that as distributed, emergent, and relational phenomena, digital infrastructures are paradoxical in having to contend with logics of both change and control across infrastructural layers. A critical concern in infrastructural research has thus focused on the tensions arising from managing opposing logics in interconnected systems.

From the mid-1990s, a substantive body of literature has examined the theme of control and flexibility in infrastructural projects. Hanseth, Monteiro and Hatling (1996) identify the tensions produced when the irreversibility of standards both enable and constrain infrastructural momentum. Timmermans and Berg (1997) propose the notion of "local universals" to convey the vital interdependency between standards and work practices, arguing that effort is required to keep this relational dynamic going, with standards helping to manage tensions involved in transforming work practices. Developing this theme, Hanseth and Braa (2001) maintain that in infrastructural work, "managing dis-order… is just as important as creating order" (p. 288), and Ellingsen and Monteiro (2006) find that using standards to enforce order across multiple local settings can produce disorder or require additional work elsewhere for other users. Given

these relational tensions, approaches to managing infrastructural projects emphasize the importance of ongoing strategiz*ing* rather than one-off strategic alignment (Ciborra et al. 2000).

Research on the design of infrastructures has further explored tensions in practice, proposing the term "infrastructuring" to emphasize ways of accommodating the dynamic complexity of digital infrastructures (Hanseth & Lyytinen 2010; Pipek & Wulf 2009). A central question for scholars in this area is how to design infrastructure to be malleable enough for local practices while providing common formats and interfaces for coordinating work at scale in an industry. Processes of standardization have been pivotal in this regard because the rules, norms, and formats of standards enable new forms of stability and generativity that become core to process and service innovations (Tilson et al. 2010). By controlling what is included and what is excluded from infrastructural flows such as supply chains, industries achieve synergies and efficiencies at a global scale. Hanseth et al. (1996, p. 416) observe that for complex information infrastructures the only feasible way to manage tensions of control and flexibility is through modularization — decomposing or black-boxing parts of the infrastructure:

> The effect of black-boxing is that only the interface (the outside) of the box matters. The inside does not matter and may accordingly be changed without disturbing the full system provided the interface looks the same. As long as a box is black, it is stable and hence standardized.

The theme of modularization as a way of dealing with tensions is also evident in the related literature on platforms (Gawer 2009). Concerns of control and flexibility center on how platform leaders orchestrate innovation (Gawer & Cusumano 2002; Karhu, Gustafsson & Lyytinen 2018), with boundary resources (Ghazawneh & Henfridsson 2013) assuming prominence as a key mechanism through which tensions are managed (Eaton, Elaluf-Calderwood, Sørensen and Yoo 2015; Cennamo & Santaló 2019). An architectural perspective is often adopted which highlights how modularity allows third parties to innovate while aligning with the platform's focal value proposition. This interest in value creation is consistent with a focus on strategic digital transformation, where boundary resources of digital platforms are seen to enable both collaborative and competitive dynamics (Karhu et al. 2018).

While some infrastructural research has examined the interconnectedness of global and local change during digital transformation (e.g., Rolland & Montiero 2002), most studies have focused on national or regional outcomes (Aanestad & Jensen 2011; Braa, Hanseth, Heywood, Mohammed, Shaw 2007;

Hanseth et al. 2006; Timmermans & Berg 2003). For example, Hanseth et al.'s (2006) study of electronic patient records (EPR) explores tensions between control and flexibility in efforts to navigate between national pressures for a "complete EPR" and local practices in two Norwegian regional hospitals. Broader notions of generative mechanisms (Henfridsson & Bygstad 2013) in digital infrastructures have been theorized across multiple cases, but few empirical studies involve detailed, longitudinal considerations of the interplay of standards with strategic actions in industries undergoing multiple waves of digitalization. As this relation is of particular interest in our study, we next turn to the existing research on standards and digital transformation.

Standards and Digital Transformation

Standards are "a uniform set of measures, agreements, conditions, or specifications between parties (buyer-user, manufacturer-user, government-industry, or government-governed, etc.)" (Spivak & Brenner 2001, p. 16). They are created through a voluntary process of consensus building and then approved by a recognized body whose aim is "the achievement of the optimum degree of order in a given context" (ISO 2019). Once established and institutionalized, they become authoritative norms within an industry, guiding and governing action, steering how organizations operate, patterning how work is done, managing the flow of transactions, and determining how connectivity is achieved (Busch 2011; Yates & Murphy 2019). As such, standards can be thought of as structuring mechanisms that are implicated in the ongoing production of worlds (Bowker & Star 1999).

The IS field has produced a wide-ranging body of knowledge about standards, examining how they emerge, how they are maintained or transformed, and how they become obsolete (Lyytinen & King 2006; de Vries & Egyedi 2007; Narayanan & Chen 2012; Shin, Kim & Hwang 2015). Notable themes within this research include competitive dominance (Kraemer & Dendrick 2002), standards adoption (Hovav, Patnayakuni & Schuff 2004), standards setting (Nickerson & zur Muehlen 2006), network effects (Liu, Kemerer, Slaughter & Smith 2012), IT standardizing (Li & Chen 2012), partnering strategies (Venkatesh & Bala 2012), and standards compliance and liability (Lee, Geng & Raghunathan 2016).

The notion of standards as relational and materially consequential emerges in the work of many scholars in this area. For example, West & Dendrick's (2000) in-depth examination of Japan's PC-98

architectural design offers a processual analysis of the rise and fall of industry standards. Departing from the trope of "standards wars" (Cusumano & Yoffie 1998; Shapiro & Varian 1999), this approach enables West & Dendrick to emphasize the relationship between layers of architectural control and standards (in)compatibility, not only in making and breaking businesses, but also in shaping an industry over time. In their research, Bala & Venkatesh (2007) found that firms' adoption of interorganizational business process standards helped them realize the benefits of interorganizational relationships such as enhanced process integration, deeper cross-enterprise relationships, and improved firm performance. Paradoxically, such relational benefits could also lead to reduced interoperability when standards construct boundaries as well as remove them. In the case of rights management, for instance, established standards depend on barriers to wider interoperability for differentiating regional offerings such as digital books and digital video streaming (Chellappa & Shivendu 2003).

In further work, IS researchers have focused on processes of standardization and the complexities this has generated on the ground (Damsgaard & Truex 2000; Hanseth & Bygstad 2015; Hanseth et al. 2006). It is widely recognized that information infrastructures become the "embodiment of standards" (Star & Ruhleder 1996), and that what is at stake is how, when and why infrastructures become standardized. For example, the body of work examining the digitizing of standards explores the role of alliances (Backhouse, Hsu & Silva 2006; Sahay 2003) and the power of dominant organizations to effectively legislate standards (Markus, Steinfield, Wigand & Minton 2006). These studies highlight how different forms of governance are used to stabilize the deployment of standards across time and space. This is a particularly acute challenge because as structuring mechanisms that produce order, standards are a "collective achievement" (Yoo, Lyytinen & Yang 2005) that must scale contexts while allowing adaptability to local requirements (Braa et al. 2007).

Summary of Literature

The digital transformation literature has foregrounded the strategic changes associated with digital innovations, along with the infrastructural work that sustains such changes. Much has been learned about the digital transformation of processes, services, and products that enact the value propositions of enterprises (Yoo et al. 2010a), as well as how digital infrastructures and standards embody a paradox of

control and flexibility in supporting digital innovations at industry levels (Tilson et al. 2010; Yoo et al. 2005). While this is important work, further research is needed to explicitly examine the consequences of strategic digitalization efforts for the industry standards that structure core business activities.

In examining how waves of digitalization affect industry standards, we found it useful to extend the metaphor of waves. Waves occur on the surface of water. Yet, all bodies of water have a visible surface and a less visible undersurface. The two are inextricable, part of the same body of water, and shifts in one necessarily influence the other. We borrow the oceanographic notion of "undertow," which refers to the offshore-directed flow of water produced by and moving beneath shore-approaching waves. Mostly hidden from view, the undertow moves in relation to the waves but can generate unexpected pressures and outcomes. We propose the notion of "digital undertow" as an evocative metaphor to theorize the changes to industry standards occurring beneath the waves of digitalization and generated by them as a corollary effect (see Figure 1).

The digital undertow is the unwitting yet consequential effect of digitalization efforts that are aimed at core business activities. It resonates with prior research on technological change that found such efforts routinely produce unintended consequences (Majchrzak et al. 2016; Orlikowski 2000). Scholars have variously conceptualized these changes as drift (Berg 1997; Ciborra et al. 2000), side effects (Hanseth et al. 2006; Scott 2000), emergence (Boudreau & Robey 2005; Orlikowski 1996), and complementarities (Brynjolfsson & Hitt 2000; Ennen & Richter 2010). Arising from strategic initiatives, these unintended consequences produce a wide range of unexpected outcomes from planned developments.

For example, complementarities refers to the idea that in particular phases of digital transformation, further value can be generated by combining different activities and resources so that these reinforce and leverage each other, creating value-adding synergies for firms (Brynjolfsson & Hitt 2000). The concept of emergence is associated with organizational transformation efforts that generate unexpected shifts in organizing practices as these respond to the opportunities and challenges of new technologies (Orlikowski 1996). Relatedly, side effects involve changes that overflow their intended scope, producing unexpected outcomes that may challenge established ways of doing things and increase uncertainties (Beck, Giddens & Lash 1994). For instance, as Hanseth et al. (2006) find, efforts to increase control and stability through

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standardization can in certain cases generate instability as side effects increase complexity and fragmentation. The idea of drift (Ciborra et al. 2000) similarly recognizes that infrastructures have the tendency to deviate in practice from their planned purpose or strategic intent, and end up producing surprising and unplanned effects.

Our notion of the digital undertow as a corollary effect of digital transformation relates to these prior ideas, but differs in its specific focus on the distinctive and unwitting changes to industry standards that result from digitalization efforts but are not manifestly part of them. In particular, we provide grounded insights into the processes that produce the digital undertow by explicating the relations between industry standards and materializations of the phenomena they structure. When digitalization efforts change how firms' core activities materialize, these changes affect the capacity of industry standards to effectively coordinate and regulate industry-wide operations. We argue that corollary effects of digitalization on industry standards constitute an important and understudied digital transformation with significant implications for industries going forward. We turn now to the approach that we used to pursue this focus in our research.

Theorizing Industry Standards as Apparatus

We found the concept of apparatus (Barad 2007) to be especially helpful in articulating the notion of the digital undertow. While the term apparatus may evoke images of equipment in a laboratory, seemingly static or arbitrarily arranged, we regard apparatuses as bounded, material practices that organize the world in particular ways (Orlikowski & Scott 2014; Scott & Orlikowski 2014). Instead of centering on actors or artefacts interacting within a context, a focus on apparatus helps us understand industry standards as processes that constitute the phenomena they structure. Industry standards do this by coordinating and regulating industry-wide operations, while also creating the conditions of possibility for new actions and outcomes to emerge. This approach allows us to join with others who have recognized that as digitalization continues, it becomes generative in novel and unexpected ways that warrant examination (Lusch & Nambisan 2015; Nambisan et al. 2019; Tilson et al. 2010; Yoo et al. 2010a; Warner & Wäger 2019; Zittrain 2006).

Understanding industry standards as apparatuses helps us investigate two ways in which they organize the phenomena they structure. Standards organize phenomena by marking out particular recurrent actions as salient for coordination across time and space. As Timmermans & Berg (2003, p. 211) observe, standards coordinate industry-wide activities, flows, and relations in a way that is "everywhere applicable, everywhere similar." Standards also organize phenomena by distinguishing and managing difference. In doing so, industry standards define the boundaries of their jurisdiction and operationalize the rules and guidelines that regulate how core business activities are enacted in practice.

Within our study, the concept of apparatus helped us understand the book industry as entangled with its industry standard, the ISBN, and focused us on how its industry-wide operations were structured by the rules and guidelines of the ISBN. It led us to examine the ways in which the material practices of the ISBN apparatus included and excluded different aspects of the phenomenon (the book) it structured over time. While exclusions from an apparatus often go unnoticed and unremarked, they are nevertheless constitutive, making a difference to what is produced in practice. As we detail in the findings, by attending specifically to what and how the ISBN apparatus included and excluded over time, we are able to explicate how changes in materializations of the book transformed the capacity of the ISBN standard to coordinate and regulate industry-wide activities, flows, and relations.

RESEARCH METHODS

Our research study was focused on understanding processes of digitalization in the book publishing industry. We systematically gathered data from multiple sources over a period of four years (2014-2018), combining examinations of current practice with historical analysis. The particular historical approach used in our study was motivated by our findings and informed by the technique of genealogy. Before explaining how this was developed and operationalized, we describe our corpus of data.

Our study involved a total of 125 interviews but as detailed below, in latter phases we focused primarily on the 56 interviews that dealt with book standards and the ISBN (see Table 1). Purposive sampling motivated the selection of interviewees (Silverman, 2014), prompting us to identify and select individuals or groups of individuals with expertise or experience relating to our research interest in

digitalization. These participants included active and former employees working at different types of publishing houses (trade, scholarly), standards agencies, trade associations, libraries, industry information services and intermediaries, as well as independent industry experts (consultants, analysts, researchers). We supplemented this with participant observation materials including field notes and research memos documenting our multiple forms of engagement in major industry conferences (e.g., the *Frankfurt Book Fair)* as well as attendance at standards summits, training courses, and publisher events.

Initial interviews were open-ended and exploratory as we learned about different forms of digitalization within the book industry. We were interested in how the shift to digital was manifesting on the ground in the industry, and what challenges and opportunities were being generated as a result. Our questions inquired about digital innovations, and how practices and products were changing in the publishing industry. Later interviews became more focused, centering on participants' experiences with book production, distribution, and sales, in both print and online. We asked participants to walk through the processes of producing or marketing digital books, to speak to how these differed from the processes for print books, and to describe the consequences of those differences.

The first phase of data analysis was inductive with iterative rounds of coding using techniques of grounded theory (Dougherty 2002; Langley 1999; Strauss & Corbin 1990) that allowed us to identify thematic categories while remaining open to emerging ideas. We had been focusing on how digitalization was changing work practices in book publishing, but we repeatedly heard accounts of how this process was generating strains and ambiguities in use of the well-established ISBN standard. Following a long period of stability during which time the ISBN had become the taken-for-granted structuring authority in the industry, a spirited debate was taking place about its relevance (or lack thereof) in the contemporary digital age. An important puzzle thus became apparent: why was the ISBN, a prime example of a highly successful industry standard, struggling in the face of current digital innovations?

In attempting to understand more deeply how and why recent waves of digitalization were having such unexpected consequences for standards in the book industry, we tailored the next phase in our analysis to investigate these present-day tensions. This is the goal of genealogical analyses, a historical technique largely developed by Foucault (1977, 1981) that produces insightful accounts that relate to the critical

question: 'how did we get *here.*' We began by focusing our attention on the 47 interviews in our corpus that dealt explicitly with book standards and the ISBN. We conducted nine further interviews with industry and standards experts on issues and tensions associated with book standards and digitalization. Our questions inquired about the role of the ISBN in the industry, how and why it had been revised over time in response to multiple digitalization efforts, what were previous and current challenges to its use, and how were these challenges experienced and addressed within the industry.

Alongside these interviews, we gathered historical archival material related to the ISBN, including publications and documentation from professional standards organizations. We also collected the work of academic-practitioners involved in the development of book industry information systems, annual reports of regional and international standards bodies, and white papers discussing updates to standards published by industry associations, most notably the Book Industry Communication (BIC) group in the UK and the Book Industry Study Group (BISG) in the USA. We assembled an archive of trade press articles from *The Bookseller*, a weekly magazine founded in 1858 that reports on the latest news about book publishing and selling. We sought out original documents referred to in the business history of the W.H. Smith company, which details its practices and leadership in book standards development. The *Book Lives* archive in the British Library provided access to audio recordings with industry leaders who had worked in UK book publishing and selling between the early 1920s and 2000s.

In conducting our genealogical analysis, the broad range of archival material was particularly helpful for understanding the early development and challenges of the ISBN, while the interviews informed more recent issues with the ISBN emerging in the present day. The distinctive genealogical strategy we followed makes a purposeful analytical turn by examining "the constitutive aspects of discursive practices *in their materiality*" (Barad 2007, p. 57; emphasis added). Most genealogical studies, including those in management research (Jordan 2017; Miller & O'Leary 1987; Prasad 2009; Schwartkopf 2015), pursue language-based strategies centered on discourse or narrative. We took the working principles that characterize genealogical approaches — diagnosing 'the present' and problematizing 'how we got here' (Garland 2014; Hook 2005) — and focused these on analyzing how and why the ISBN apparatus materialized differently in practice over the five decades of its use in the book industry. By examining

what, how, and why different materializations of the ISBN apparatus included and excluded over time, and relating these to successive waves of digitalization, we came to understand why digitalization was generating such significant challenges to the continued viability of the ISBN in the book industry.

Our *process of diagnosing* the present situation traced how the ISBN rules and guidelines were differently enacted over time, both by various standards authorities and by the industry on the ground. We examined how the boundaries demarcating activities, flows, and relations with respect to contemporary book formats related to the current specifications of the ISBN apparatus. We then traced these differences back through shifts in the ISBN, comparing different editions of the rules and guidelines as published by ISO (the International Organization for Standardization), the standards authority for the ISBN. While such changes were not of primary concern to the strategic side of publishing where digitalization was transforming the production and marketing of books, they were of acute importance in the back offices where there was considerable evidence that sizable tensions were building around effective use of the ISBN standard in the present day.

We compared the experiences of dealing with ISBN problems on the ground as recounted in our contemporary interviews with those raised by historical industry commentary in the archival materials. Examples of ISBN problems we documented include missing, erroneous, or duplicate ISBNs for print books, e-books that should be available in particular regions that were not, and customers buying certain e-books only to find completely different books rendering on their electronic devices. The diagnosis process thus allowed us to identify specific ISBN changes over time and the different problems associated with their use on the ground. We articulated this understanding by mapping the multiple enactments of the ISBN apparatus over 50 years, tracing through its salient continuities and discontinuities (see Figure 2). Having understood the present situation, we turned to questions of how and why this was so.

Our *process of problematizing* focused on the continuities and discontinuities in the ISBN, and inquired into the conditions of possibility for different versions of the ISBN to be enacted at particular times. Our theoretical orientation to apparatuses attuned us to how different ISBN versions entailed certain inclusions and exclusions (Barad 2007), and how these made a difference to the ways in which core business activities were coordinated and regulated in the book industry. Focusing in particular on

constitutive exclusions helped us associate each discontinuity with distinctive changes in the ISBN apparatus. This highlighted the different aspects of the book that were excluded from the ISBN's coordinative and regulatory reach over time. We related these constitutive exclusions — both those enacted by standards authorities and by firms in the industry — to particular tensions with use of the ISBN in practice. Distinguishing among types of tensions, specifically tactical, pragmatic, and existential challenges, helped us explain why some exclusions enacted by the ISBN generated tensions that were temporary and marginal, while others generated tensions that were persistent and severe.

Through the genealogical analysis of diagnosis and problematization, we came to understand the apparatus of industry standards as always in relation to specific materializations of the phenomena they structure. Within the book industry, the phenomenon being coordinated and regulated is the book. During the first and second waves of digitalization in the book industry which digitized processes and services, the design, implementation, and revision of the ISBN standard retained its correspondence with the specific materialization of the book as a physical product. The third wave of digitalization in the industry digitized products, considerably changing how the book materializes. No longer existing as persistent, physical products with well-defined boundaries demarcated by fixed spines and covers, digital books materialize as digital files encoded in diverse digital formats that display dynamically on a variety of electronic devices. Such a substantial material shift crucially alters the activities, flows, and relations associated with digital books, challenging the capacity of existing ISBN rules and guidelines (premised on print books) to effectively structure the digital book trade. This loss of correspondence is generating significant tensions with use of the ISBN standard on the ground, undermining its value and authority in the present as well as going forward. This is the account we develop next.

DIGITALIZATION AND THE ISBN INDUSTRY STANDARD

For over 50 years, the ISBN has occupied an unrivalled position in the book industry, coordinating and regulating core business activities throughout the global book trade. Daily use of book standards has been largely stable, efficient, and productive. How then have we arrived at the present situation where current practice is replete with significant tensions raising critical questions about the future of the ISBN? Why is

the ISBN, widely acclaimed as "the most effective product identifier ever established," now confronting critical concerns that it "may be unable to thrive in the 21st century as it has over the past 40 years" (Cairns 2009)? Our genealogical approach allowed us to trace the conditions of possibility for this paradoxical situation. By inquiring into how and why the ISBN has been differently enacted over time, we were able to relate the waves of digitalization (Tilson et al. 2010; Yoo et al. 2010a) strategically transforming the book business to processes of the digital undertow that are transforming the ISBN industry standards.

We first examine the entanglement of the ISBN with early waves of digitalization that focused on book industry processes and services. Figure 2 shows the continuities and discontinuities in ISBN use that were enacted over this period (mid-1960s to early-2000s), as the industry's supply chain, information flows, and communications were digitized. We call out the tactical and pragmatic tensions with the ISBN that emerged, showing how some were transitional and others remained peripheral for a number of decades. We next consider changes to the ISBN that are related to the recent third wave of digitalization that has focused on products. Figure 2 shows the further continuities and discontinuities in ISBN use that were enacted over this period (mid-2000s to 2020). We draw attention to the existential tensions that are currently emerging, and indicate how and why these are proving to be particularly acute and pivotal at this present time.

First Wave of Digitalization: Developing the ISBN Industry Standard

In the 1960s, the organization of the book trade was fragmented and chaotic, requiring considerable labor-intensive form filling to manage the flow of books through the supply chain. As Striphas (2009, p. 92) notes, conditions on the ground at this time were "haphazard, idiosyncratic, … costly, time-consuming, and prone to error." In such circumstances, keeping track of an ever more varied and fast-moving inventory became a serious challenge for both book publishers and retailers. The first wave of digitalization occurring in this period converted analog functionality into equivalent digital materializations (Tilson et al. 2010; Yoo et al. 2010a), ushering in opportunities to address the tactical challenge of inconsistency and fragmentation.

Among the first to take advantage of the digital opportunities was the British bookseller W.H. Smith, implementing the company's new warehouse computer-based information system in 1966 (Wilson 1985). The company sought not only to digitize its inventory but also to keep track of the flow of books from publishers and distributers. A sizable hindrance to accomplishing this was the reliance of firms in the book industry on their own proprietary book identification schemes. The executive director of the International ISBN Agency detailed the problems and inefficiencies this produced (Tagholm 2015, p. 15):

> To order or sell a book even as late as the 1960s was undoubtedly a more confusing and time-consuming process than it is now. There was no commonly accepted approach that publishers could use to identify their publications and every bookseller had a different way of ordering books. Without an industry accepted identifier, booksellers had a difficult job making clear which edition of a book they wanted. Amid all the different versions of each of the plays of Shakespeare, or of the novels of Dickens, multiple pieces of information had to be quoted and verified to make sure the bookseller received the right edition.

These difficulties on the ground coupled with growth in the size and diversity of the book market generated the conditions that prompted the book industry to investigate standardizing book identification. While the digitizing of inventory management created the potential for industry-wide efficiencies, these were excluded by the extensive reliance on proprietary book numbering schemes across the book trade. Without a standard book identifier in widespread use across the book industry, common ways of operating are infeasible. W.H. Smith again took the lead here, developing a 9-digit code referred to as the Standard Book Numbering system (SBN) that was implemented first as the key book identifier for its internal systems, with an eye to propagating its use across the industry (Foster 1966).

The initial success of the SBN to streamline W.H. Smith's operations drew the support of the British Publishers Association's (BPA), which recognized that the presence of a unique and simple book identifier would allow bibliographic control (Charkin 2015) and facilitate industry-wide communication. Griffiths (2015, p. 48) further suggests that the simple format of the standard book number facilitated its subsequent adoption across the British book supply chain as it was being digitized:

> Computerization was in its infancy at that time, yet [the SBN] because it was a short "code" that could be verified and processed easily by machines, quickly became an essential building block in the automated systems then being introduced by retailers, libraries, and publishers.

Recounting this history, Ehlers (2000) similarly emphasizes automation as "the driving force" for advancing "the idea of a standard book number for universal use" (2000, p. 27). Standards expert, Laura

Dawson, highlights how book standards were developed as a result of early digitalization efforts within the industry, which changed how inventory and distribution operations were materializing:

> The ISBN was invented in the late 1960s when warehouses first began using computers. Digital is why ISBNs exist in the first place! (quoted in Webb 2013)

Within a year, the SBN was adopted as the *de facto* standard book code by over 1,600 publishers in the UK (Striphas 2009), moving it away from an identifier used by a single retailer to one generally deployed throughout the British book industry. The use of a standard book number spread quickly, first to the US and then to other countries, and by 1967 the SBN served as the basis for proposing a world-wide book identifier standard. In 1970, a 10-digit international SBN, the *International Standard Book Number* (the ISBN), had been developed and was officially ratified by the International Organization for Standardization (ISO), an independent, non-governmental, international standards organization based in Geneva. The subsequent publication of the ISBN specifications as ISO 2108 formally institutionalized the ISBN as an international standard and stimulated important shifts in how the global book industry was coordinated and regulated going forward.

Second Wave of Digitalization: Expanding the ISBN Industry Standard

The ISBN's role and value in the book industry was substantially expanded in the 1980s, when the second wave of digitalization decoupled content, services, and devices, allowing for different digital materializations of core industry activities that were more flexible and easier to connect (Tilson et al. 2010; Yoo et al. 2010a). The encoding of the ISBN in a barcode on book covers (see Figure 3) further automated distribution processes within firms, facilitating the digitizing of book selling as electronic points of sales devices (EPOS) scanned barcodes at checkout. Barcodes were already in use in other industries, and the European Article Number (EAN) was deemed the most suitable for use in the book industry. The EAN barcode specifications, however, required a 13-digit identifying number while the existing ISBN standards specified a 10-digit number, thus excluding the ISBN from serving as an EAN barcode. Such exclusion pressured the book industry to make changes, and in 1985 the ISBN format was officially revised. The expanded ISBN specifications required all existing (and subsequent) ISBNs to

append the prefix 987 to make them consistent with the EAN format, and thus able to materialize as scannable 13-digit barcodes on books.

Growth in world-wide book publication raised concerns that the industry would soon run out of ISBN numbers. The possibility that future books might be excluded from the ISBN apparatus motivated the ISBN ISO technical committee to address this tactical issue, and after a number of years, the fourth edition of the ISBN was published in 2005. This edition officially expanded the ISBN from a 10-digit number (plus 978 prefix) to a full 13-digit identifier, thus retaining ISBNs consistency with prior usage and the EAN format, while also increasing its capacity to accommodate the proliferation of published books. The industry press announced at the time that "ISO's successful ISBN book identification standard has been renewed for the 21st century."[1]

Service innovations followed process innovations, embedding the ISBN still further into everyday management and communication practices across the book industry. Prior to this, market-level insight had been limited, based on incomplete or unreliable data gathered locally and by hand. Conditions changed when the industry integration enabled by the new digital materializations of ISBN barcodes and networked sales points allowed EPOS data to be transmitted from retailers to Whitaker, an information services company. The Whitaker company (subsequently acquired by Nielsen) accumulated and analyzed the sales data across the industry, then sold the results back to publishers. Beyond information services to publishers, Nielsen introduced a business analytics system, BookScan, drawing on the "big data treasure chest" of ISBN data to generate additional market intelligence, calculating influential best seller lists, identifying market trends, and informing planning (Fisher & Richardson 1996, p. 22). As Jones (2013) observed about the widespread adoption of BookScan, "The step-change in our knowledge of the marketplace was huge." It had become the industry's "magic number" (Whitaker 1992). It is no surprise that the ISBN has been hailed as the 'jewel in the crown' of industry standards not only because it enabled effective supply chain management and digital communications, but because it formed the centerpiece of numerous service innovations in the industry.

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[1] https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/isbn0512-2.pdf (accessed October 5, 2021).

Over time, the ISBN achieved near population-level coverage and institutional stability. Governed centrally through an ISO technical committee, the ISBN is implemented locally through over 150 ISBN agencies in 200 countries and territories that assign ISBNs to more than 1.5 million publishers (Griffiths 2015). Want to know how to use the ISBN? Then search for the current edition of the ISBN standard (published as ISO 2108:2017) to learn about its specifications. Every five years, the ISBN is formally reviewed and revised to ensure its rules and guidelines reflect any relevant changes in industry practice:

> [The ISBN] is an evolving standard. There is a board … It is truly international. And there is a process, a discussion, …and they are very aware, you know, they're very much aware of the changing needs of the industry and wanting to maintain the relevance of it. Because they don't want to throw the baby out with the bathwater. (Industry Analyst)

In practice, the ISBN acts like a social security number for books enabling their unique identification throughout the book supply chain. The ISBN is relied on for authentication so much that it is seen as "fundamental to all modern bibliographic and publishing e-commerce systems" (Richardson & Taylor 2008, p. 4). According to the International ISBN Agency, the ISBN ensures "that exactly the right book is ordered and supplied in the precise format required" (Griffiths 2016). Recurrent and routine use of the ISBN brings coherence to the book trade, coordinating and systematizing daily operations, allowing "any book with an ISBN assigned to be tracked virtually anywhere" (Friedlander 2010). The ascendance of the ISBN identifier during particular time periods is depicted in Figure 2, which shows the inconsistency of pre-digital identifiers being superseded by systematic ISBN-enabled digitizing of processes and services with continued adoption and implementation of the ISBN throughout the global book trade. At the center of Figure 2, we see that by the early-2000s, an almost-universal consistency in use of the ISBN standard had been achieved for all books in print.

Early Tensions with the ISBN Industry Standard

As the SBN and ISBN standards were being developed and deployed, a number of practical difficulties and strains became evident. These pragmatic tensions manifested in two primary ways — publisher resistance and usage problems (see Table 2). Such tensions generated local action and response, but were temporary or peripheral in the first few decades of ISBN use.

Resistance. With W.H. Smith's roll-out of the SBN and its endorsement by the BPA, pressure on UK publishers to adopt the standard numbering system grew. Initially, some publishers were skeptical about the value of a standard numbering system for books. Ehlers (2000, p. 26) recalls:

> Most publishers had to be convinced that a unique number for each title or edition was necessary. Even more difficult was to persuade publishers that this unique identification should appear on each book.

Other publishers resisted because of a preference for their own in-house identification methods. Tagholm (2015, p. 15) describes one such dissenter and the swift response that followed:

> Macmillan originally refused to adopt SBNs until it was contacted by one Gerry de Knop, then head of supplies at the Greater London Council. He wrote: 'You are our largest educational account. We are computerizing our warehouse procedures. We will of course go on buying selected items from you. As we will have to apply numbers ourselves, we will expect a very substantial discount for the manual handling of those books we continue to buy from you.' As Griffiths [head of the International ISBN Agency] says: 'This rather bottom-line approach certainly seemed to do the trick—Macmillan numbered the whole of their backlist over the weekend after receiving Gerry's letter.'

With the institutionalization of the ISBN as an ISO standard, publishers around the world were under pressure to implement the ISBN within their systems. The process of integrating the ISBN into routine publishing practice proceeded slowly. Striphas (2009, p. 95) reports that a number of firms resisted for practical reasons:

> [A] dozen years into its implementation both the idea and practice of universal book coding continued to meet with resistance … Part of the reason was pragmatic. As efficient a system as the ISBN was in theory, every number still needed to be input manually at one or more points in the supply chain.

The inclusion of scannable ISBN barcodes on book covers helped to address the practicalities of data entry, but it also raised a new concern. Some UK publishers strongly objected to the barcode, believing it destroyed the visual effect of their cover designs by looking, as one put it, "ugly." In a now-familiar response, the arm-twisting of powerful players effectively subdued this resistance. Using its influence as a major book retailer, W.H. Smith insisted that publishers put barcodes on books; if they refused, W.H. Smith would not carry their books. As UK industry veteran, David Whitaker commented, "When [W.H. Smith] said 'Jump!' publishers tended to reply 'How high?'" (quoted in Charkin 2015). Eventually, most publisher opposition to the ISBN (and the use of barcodes) was overcome.

Usage Problems. When a book is assigned the wrong ISBN, it is effectively lost to both the supply chain and to readers. Among the first to realize the potential of the ISBN to lose as well as track books in practice was the bookseller W.H. Smith. As Budworth (1991, p. 111) observed:

The importance of accuracy became ever more acute as time went on. It was vital when the [ISBN] system became the cornerstone of library and trade databases and systems. W.H. Smith began to lose books into 'black holes'. This was a name given to a void into which details of books fell, when the wrong ISBNs were assigned. An ISBN is a label. If it is wrong then the product is lost from records.

In some cases, problems arose when a publisher issued duplicate ISBNs for different books, whether due to reuse or error. One observer noted:

The ISBN should be unique but a publisher could reuse ISBN's from out-of-print titles, or simply make a mistake and assign duplicate numbers to different titles. So occasionally, you will run across different titles with the same ISBN. (Industry Commentator)

A further variation in ISBN usage arose in 1994 when print books began to be sold online with the launch of Internet retailer Amazon. Speed and accuracy in operational performance became Amazon's hallmark in no small measure because the ISBN facilitated efficient supply chain management and digital coordination of book flow. However, Amazon's reliance on the ISBN identifier proved short-lived. Its software engineers concluded that while the ISBN may be a reliable identifier for physical book stores, it did not serve the demands of online retail systems. In the former, the few inaccuracies that cropped up with the ISBN could be resolved by turning to the book itself. Physically picking up a book to look at its spine, turning to the front matter, or consulting the barcode on the back, easily settled questions about identification. Such inaccuracies were much more problematic in online systems where the only point of reference was the identifier field in an electronic book record. If that identifier could not be relied on, the online retail system could not operate. A former Amazon employee explained:

The ISBN unfortunately is not unique. It's supposed to be. A lot of publishers buy a bunch of ISBNs and they have to tell Bowker [the U.S. ISBN Agency and sole supplier of ISBNs in the United States] when they're buying them what titles they're associated with. Or else they buy it for a particular title and then that book doesn't get published. Or the title gets changed or they decide they're going to do something completely different with the ISBN. And they don't notify Bowker because they've already bought it from Bowker and they've moved on. So we would get duplicate ISBNs and we'd get inaccurate ISBNs into our system, and the engineers said, 'What the hell is going on here? We can't rely on this number. It's not unique.' So hence the ASIN [Amazon Standard Identification Number] was born. And the ASIN is simply an acquisition based [number]. It's just numerical according to what comes next. There's no magic behind it. … All it is, is an absolutely reliable unique identifier that Amazon can use throughout its workflow to identify an object without any question.

What the move to online sales revealed was that once the ISBN was encoded in online systems and unrelatable to the physical book's spine, it was no longer sufficiently reliable as a book identifier. Amazon's development of the ASIN was a pragmatic workaround, and while Amazon's systems no longer

relied on the ISBN as a book's identifier, it continued to be included as descriptive metadata within a book's electronic record, thus allowing the ISBN to be displayed and searched online.

Third Wave of Digitalization: Displacing the ISBN Industry Standard

In the late 2000s, the third wave of digitalization hit the book industry, digitizing the industry's core product, the book, and significantly transforming how it materializes. On November 19, 2007, Amazon released its first e-book device, the *Kindle* for $399, which sold out in under six hours. While digital readers were not new — the Rocket eBook was released in 1998 and the Sony Reader in 2004 — it was the design of the Kindle (a wireless, lightweight, handheld device with a clear display screen) along with the increasing availability of digital books on the Amazon website (which sold for $9.99 compared to the $12 to $30 cost of a typical print book) that made for a successful launch (Khan 2017). Other e-book devices soon followed, such as the *Nook* (Barnes & Noble) in 2009, the *iPad* (Apple) in 2010, and *Kobo* (Rakuten) in 2011. Since then, e-book devices have experienced considerable enhancements so that the market today includes multiple generations of devices, each configured differently with an array of storage and display capacities and running a variety of operating software.

As the book industry continues to digitize its products, both diversity and multiplicity are evident in how content materializes. There are currently over twenty publishing formats for digital books,[2] with the dominant ones including Mobi and AZW (for Kindle), EPUB (for devices such as iPad, Nook, Kobo), HTML (for web browsers), and PDF (for device-independent usage). When considered together, new digital book formats and electronic reading devices have spawned a generation of innovations through which novel materializations of digital content are manifesting. Such heterogeneity and variability in digital books have challenged the relative stability and coherence of print book operations, raising a vital question for ISBN authorities: how to include the multiple, novel, and dynamic digital materializations of the book within the ISBN specifications?

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[2] https://en.wikipedia.org/wiki/Comparison_of_e-book_formats (accessed October 5, 2021).

Before 2007, the book had been produced in a few relatively stable and coherent formats, most

commonly hardcover and paperback. With a small number of distinct formats, the rules for assigning

identifiers to books were relatively unambiguous: each different format of a book (e.g., hardcover,

paperback) requires a different ISBN. As an ISO committee member noted, "The thing that's been

consistent from the standards perspective is that each time you have a different format you need a

different ISBN." This clarity and simplicity of ISBN rules for print books resulted in strong compliance

by publishers, with most books being assigned two to three ISBNs (one for each of the different formats

in which they materialized). When e-books emerged, the ISO standards committee extended these

existing rules to digital content, requiring a unique ISBN for each different e-book format (PDF, EPUB,

HTML, etc.). For the ISBN authorities, this was the only consistent way to distinguish among the

different digital materializations of a book available throughout the supply chain. For example, the PDF

version of an e-book materializes as a different digital file than that same book in an EPUB format, and

these distinct formats must be differentiated in the marketplace: "When there are different formats

available that operate on different devices or software programs, the end user has to know what format to

order" (ISBN FAQs, pp. 6-7).[3]

In addition to multiple digital formats, e-books often have different usage constraints, specified by

each book's digital rights management (DRM). These control what can be done with the content, for

example, which regions it can be sold in, whether it can be copied, printed, or distributed, etc. Given that

different formats of a single e-book may have different usage constraints, the standards committee ruled

that distinct ISBNs are required to distinguish among the different usages.

> [I]f you have different usage constraints that you're offering — in other words, with this book here I'm
> going to let you print some pages, but in this other version of the same book you can't. If you had that
> kind of scenario with different usage constraints available … you need a new ISBN. In other words, the
> book which says you can print from it has ISBN number one, and the same book that says you can't
> print from it and you can't lend to a friend, or whatever, that has to have a different ISBN. … You've
> got to differentiate those in the marketplace … it has to be identified. (ISO Committee Member)

A recent development facilitated by the digitizing of product is the process referred to as "unbundling

the book," whereby content is broken into smaller parts and sold in various (re)combinations as discrete

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[3] https://www.isbn-international.org/content/isbn-users-manual/29 (accessed October 5, 2021).

products for different audiences. The process of disaggregation/reaggregation is generating novel

opportunities for customizing content into multiple different 'micro-formats' or 'mash-ups' that can be

traded in various ways to different audiences:

> [Digital] also gives us the flexibility to do a lot of interesting things with content. So because we
> have modular content now … we have the flexibility to do a whole bunch of interesting stuff with
> that content. … We don't think of books, we think of modules. We've got 15,000 of them across 20
> subjects. So that's the flexibility we kind of push towards in this new world. (Publisher)

Further publishing innovations are also emerging, including experiments with web-based channels for

sharing and selling digital content. Referred to as "books in browsers,' such an approach uses web

browsers to display dynamic and personalized digital content to readers. What is being challenged with

this development is the long-standing materialization of a finite book as the only way to produce and sell

content, an approach known in the industry as the 'book as container' (McGuire & O'Leary 2012):

> [There is] a movement towards looking towards new business models for content, and stop being so
> focused on e-books having to be these things that are packaged up like an actual file that you
> download and can only read locally. Because that's really limiting the power. … [And] something I'm
> really excited about is that once things are on the open web, people can link to things, people can link
> out. It creates all these interconnections that really are impossible to foster right now. (Publisher)

While the ISO standards committee has not explicitly ruled on such unbundled, mashed-up, or web-

based formats, a number of standards experts have contended that different modularized materializations

of the same content should abide by ISBN rules and guidelines:

> It's now possible to sell individual parts of a book, for example, chapters or other elements. It's
> important to note that if, as a publisher, you intend to produce and monetize these different, micro-
> formats, each one will require a separate ISBN if it's going into the supply chain. Publishers fear the
> complexity of assigning ISBNs to all the different formats they might produce, but if you plan to
> make your product range more diverse, you'll need to so that all your products are identified.
> (Executive Director of the International ISBN Agency)

One exception to the ISO ruling about ISBN assignment for different book formats is the case of books

that do not enter the supply chain. With print books, only a small number of books (often produced by so-

called "vanity presses" and distributed for free) were unavailable in the broader marketplace. The ISO

ruling on these books was that as they did not enter the general supply chain, they did not require an

ISBN, and were consequently excluded from its purview. In considering the situation for e-books, the

ISO standards committee retained consistency and extended the existing rule to digital books that do not

enter the supply chain.

> The main nuance is whether or not something is in the supply chain, because ISBN is a supply chain identifier. So, if the edition, the format, the version, whatever you want to call it, is only available from one source, you do not need an ISBN for it at all, because the picture is clear: you can only get it over here, nowhere else. (ISBN Agency Member)

The most notable digital book to be affected by this ruling is the Kindle e-book from Amazon. Amazon's Kindle e-books are materialized in one of Amazon's proprietary digital file formats (Mobi, AZW, AZW3, KF8, or KFX), electronically transmitted directly from a publisher to Amazon, sold on Amazon's online retail platform, and then delivered through a direct electronic download onto a designated digital device (the Kindle device or the Kindle app running on a smart phone, tablet, or computer). This is the only way for Kindle e-books to materialize in the world, and no other way for them to be bought and sold in the marketplace. As such, these proprietary digital materializations do not enter the general book supply chain, and are consequently excluded from ISO rulings on ISBN assignment.

Current Tensions with the ISBN Industry Standard

Despite the extensive role of the ISBN in computerized supply chain management, digital communications, and information analysis, the recent digitization of the book has produced tensions with use of the ISBN that are becoming especially pressing within the industry. These are manifesting in three ways: resistance, usage ambiguity, and non-usage (see Table 3).

Resistance. Publishers have responded variously to the new ISBN rules for digital books. A few are reluctantly following the rulings, but many others are resisting, choosing to deviate from the official rules by assigning the same ISBN to different digital formats of the same e-book.

> The best practice is considered to assign a separate ISBN to each of the [eBook formats] so they can be differentiated. But that means a lot more duplication of effort because 99% of this data is the same. Do I want to create five different records for these products that are essentially the same except for this one fact about them? So, we don't do that. (Publisher)

The variability in commitment to and compliance with the ISBN rules for digital formats were evident in a 2011 study by the US Book Industry Study Group (BISG), which reported "wide interpretation and varying implementations of the ISBN e-book standard" in the book supply chain (Cairns 2011), a finding acknowledged by the ISBN authorities:

> The publishers were very negative about [the ISBN e-book ruling]. … I think maybe people are just terrified of having to keep track of all these ISBNs and get their metadata right. (ISBN Agency Member)

Reasons for resistance include complexity and administrative overhead to manage multiple metadata files for books with distinct ISBNs, and the cost of acquiring ISBN numbers (in countries such as the US, UK, and Japan, publishers have to purchase ISBNs from national ISBN agencies[4]). Curtis (2009) explains:

> Each [e-book] format requires its own ISBN, requiring publishers to register as many as seven or eight of them plus additional ones for print and audio editions. It's a huge clerical and bookkeeping headache for publishers and no inconsequential expense.

We found publishers routinely bypassing the ISBN ruling, a practice noted by others in the industry.

> The idea that each and every e-book format should have an individual ISBN has one major flaw: as the number of e-book formats proliferates, which it clearly is doing, the cost of this would become prohibitive unless the publisher limits themselves to only a relative few of those formats. Which is counterintuitive if one's goal is to maximize the market. (Industry Advisor, quoted in Cairns 2008)

Indeed, a publisher told us that they were constraining their digital format options to do precisely this.

> And we only want to put out one e-book file that can work on as many devices possible. So even if one device has more capabilities, we don't usually aim for it. We sort of aim for the lowest common denominator. (Publisher)

Retailers have struggled with the variability in publishers' use of ISBNs for e-books.

> Barnes & Noble and Kobo and Apple for a while were requiring e-books to have ISBNs and they needed to be separate ISBNs from the print books. What happened was that they received so many submissions from smaller publishers who were just starting to digitize and from self-published authors who had never, you know, experienced the publishing market before. All these were misusing ISBNs and really doing damage to their databases, so they finally said, 'No we can't, you know, we just can't fight this battle anymore.' And they switched to proprietary identifiers. (Industry Analyst)

Usage Ambiguity. The recent publishing trend of content unbundling, along with dynamic modularization of content into customizable micro-formats, linking of digital web content, and delivery of "enhanced" multimedia and interactive content that go beyond static text and images, has raised doubts about the appropriateness of ISBN assignment for novel digital materializations. As these forward-looking publishing initiatives are currently excluded by the ISBN standard, there is considerable ambiguity over whether and how to use ISBNs for this type of digital content. Some publishers are openly questioning the rationale for and value of the ISBN with respect to digital micro-formats:

> With the disaggregation and reaggregation of digital content, we are now able to sell individual chapters. Even paragraphs. Each of these are separately tradeable and would therefore require a unique ISBN. For a 20-chapter book available in 2 print formats and 4 e-book formats, that would mean we're approaching 100 ISBNs required per title. … [In time,] we may well find the principle of 'one ISBN per tradeable object' to be severely challenged! (Publisher, quoted in Cairns 2008)

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[4] In the US, for example, a single ISBN is available for a one-time cost of $125, ten ISBNs for $295, and a hundred ISBNs for $575 (https://www.myidentifiers.com/get-your-isbn-now) (accessed October 5, 2021).

Despite the resistance and criticism of publishers and retailers, the ISBN authorities stand by the rules: "The unwavering requirement is to identify books irrespective of whether those books are digital or printed versions" (Griffiths 2015, p. 48). The difficulties in getting industry players to adhere "unwaveringly" to the ISBN rules with respect to digital content suggests that this requirement may be increasingly difficult to achieve as digital content continues to materialize in novel, generative ways.

Non-Usage. When the ISO standards committee ruled that Kindle e-books were excluded from ISBN assignment, they were acting within their governing mandate — regulating identification and coordination of books flowing through the industry supply chain. This ruling ensures consistency with prior rulings and preserves the integrity of the ISBN with respect to print books. It also, however, has significant implications for the purpose and status of the ISBN with respect to digital books.

A particularly challenging issue is the increasing size and scale of the Amazon Kindle market that is now excluded from the ISBN's purview. In the US, Amazon Kindle books account for 83 percent of e-books sold annually (in the UK, it is about 90 percent) (Shatzkin 2018). As the number of digital books — and Kindle e-books in particular — increases, the number of books being assigned an ISBN is declining over time. This is further reducing knowledge about and appreciation for the role and value of the ISBN.

> Amazon [does not] use the ISBN for digital. … And [now] you have got this massive groundswell of people who just use Amazon ... And so, the potential for people understanding the importance of the ISBN is diminished. (Industry Consultant)

Exacerbating this situation is the exponential growth in self-publishing, estimated as a $1 billion industry (Alsever 2017), which has been greatly facilitated by the digitizing of the book. Many self-publishing authors choose to publish their books on platforms such as Kindle Direct Publishing and CreateSpace (both owned by Amazon). As both these digital platforms are exempted from using ISBNs, authors of such e-books are electing not to use the ISBN. One industry observer (Anderson 2014) noted:

> A lot of self-publishing authors have simply bypassed the need for the ISBN and created an ecosystem that you can operate in quite comfortably. You can publish, you can sell, you can make money entirely within the Amazon ecosystem and you never need go outside of that, and of course that negates the need for an ISBN.

As a result of both the growth of Kindle e-books and the increase in self-publishing, a large and expanding number of e-books are being sold online without ISBNs, essentially excluding substantial parts of the book trade from the jurisdiction of the ISBN standard.

Considering the open opposition to and questioning of the ISBN's standing and authority with respect to digital products in the industry, conditions on the ground are notably unsettled (Carlson 2011). A position paper by the International ISBN Agency noted,[5]

> The lack of consistent standard identifiers for e-books has created particular problems for the use of e-commerce and bibliographic metadata, where EDI and product description standards expect a unique identifier to differentiate separate products and have difficulty coping with the ambiguity of a single identifier for multiple products. … This state of affairs is reminiscent of the printed book supply chain in the early 1960's, when each trading partner was assigning and transmitting their own product identifiers with chaotic results.

As detailed in Figure 2, from an almost-universal consistency in use of the ISBN identifier for published books, the digitizing of the product has spawned considerable variations in content materializations and consequent variation in ISBN usage, including non-usage. While such innovations are generating new opportunities for digital content, they are adding complexity to industry practices and destabilizing the long-standing coordination and regulation of books flowing through the global supply chain. As a result, a growing number of published books (and a majority of digital books) are being produced without ISBNs or with inconsistent ISBNs, undermining the industry-wide rationale for and viability of the ISBN standard in use.

DISCUSSION

Our study addressed the research question, *how does digital transformation affect industry standards?* Drawing on our empirical analysis and the literature's identification of waves of digitalization (Tilson et al. 2010; Yoo et al. 2010a), we theorize that as waves of digitalization transform core activities of firms, they also — necessarily and unwittingly — affect the industry standards that coordinate and regulate those phenomena. Building on the wave metaphor, we observe that waves always produce an

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[5] https://readdigitalbooks.files.wordpress.com/2010/02/isbn_agency1.pdf (accessed October 5, 2021).

undertow. So too with waves of digitalization; they produce digital undertows as a corollary effect, which generates pressure on industry standards that leads to their transformation.

Industry standards coordinate and regulate industry-wide activities, flows, and relations by specifying collective rules and shared guidelines that are enacted on the ground in industry practice. Through the work of developing standards, specifications are made to correspond with distinct materializations of the phenomena being coordinated and regulated. It is this entanglement of industry standards with specific materializations of their phenomena that constitute the conditions of possibility for standards to perform effectively. When a wave of digitalization changes how firms' core activities materialize, the rules and guidelines of existing standards do not (at first) include the newly digitized materializations, and thus cannot coordinate and regulate them. The constitutive exclusions of such digitized phenomena from existing standards generate what we term *tactical tensions* that pressure the industry to revise the standards so that they do include the newly digitized materializations of firms' core activities. Following appropriate revisions or extensions to rules and guidelines, standards are re-aligned with the new materializations and resume coordinating and regulating industry-wide operations.

When, however, the new digital materializations of phenomena are especially novel and depart significantly from prior materializations, the existing standards cannot be readily revised or extended to include them. Without a major overhaul of the standards that substantially re-specifies the rules and guidelines (a costly, difficult, and time-consuming effort), novel digital phenomena remain excluded from existing standards. To the extent that these novel digital phenomena grow in scale and scope, more and more important aspects of the industry are excluded from the standards' purview, and consequently not coordinated and regulated by them. Such constitutive exclusions generate what we term *existential tensions* that threaten the purpose, value, and authority of the standards. These tensions are particularly problematic as they challenge the standards' raison d'être and their capacity to effectively coordinate and regulate the industry in the digital age.

In our process model (see Figure 4), we articulate how the successive waves of digitalization generate processes of digital undertow. These processes relate to the specific materializations of phenomena that are transformed through waves of digitalization, which critically shape whether and how industry

standards can operate. We call out the distinctive tensions that arise when particular phenomena on the ground are excluded from the purview of the standards apparatus. We theorize three different transformations of industry standards — developing, expanding, and displacing standards — and explain the processes contributing to their enactment. Drawing on Yoo et al. (2010a), we characterize the first three waves of digitalization in terms of digital replicating, digital decoupling, and digital recombining and indicate that more digitalization waves are certainly coming that will necessarily produce further digital undertows and further transformations in industry standards.

First Digital Undertow: Developing Industry Standards

The first wave of digitalization automates existing ways of operating within firms (Tilson et al. 2010; Yoo et al. 2010a). In the absence of an industry standard, this digital replication process leaves intact separate firm structures and practices. Firms' reliance on proprietary schemas excludes the use of collective rules and shared guidelines. The digitizing of firms' operations changes possibilities on the ground. Common ways of operating now become feasible and desirable, and their continued constitutive exclusion by proprietary systems becomes acutely salient, manifesting as *tactical tensions* that challenge firms to cooperate in the development of industry standards that will enable more efficient and effective industry-wide ways of operating. In the book industry, these tensions manifested as the inefficiencies of multiple proprietary book numbering schemas in the face of warehouse computerization, leading to the creation and diffusion of the Standard Book Number (SBN) within the UK. The widespread adoption and use of the SBN throughout the UK book industry generated strong evidence of efficiencies that prompted efforts to spread the standard globally, and the development of an international standard — the ISBN — soon followed.

The development of industry standards involves extensive effort and pain-staking work to negotiate the collective rules and shared guidelines that will structure industry-wide operations. The ensuing specifications are designed to correspond with the materializations of the phenomena to be coordinated and regulated. This relates the specifications of industry standards to the particular materiality of the phenomena manifesting at that time. For example, international standards for shipping containers were

specified to correspond with a few common physical sizes that could be accommodated in the typical cargo-carrying trucks, railroads, and ships of the 1970s (Yates & Murphy 2019). The standard keyboard layout QWERTY was designed to correspond with the materiality of typewriters manufactured in the 1880s (David 1985). The ISBN standard was designed to simply and uniquely identify books that materialized in 1970 as bound, physical books issued by registered publishing houses.

Developing industry standards to enact a collective way of operating in an industry takes time and concerted effort involving a number of interested parties and infrastructures. The goal in negotiating across multiple interests and different priorities is to enable the stable structuring of industry-wide activities, flows, and relations while flexibly accommodating local conditions. This typically results in the design of common interfaces (Hanseth et al. 1996; Hanseth & Lyytinen 2010), which leave the implementation details black-boxed, to be worked out by each participating firm. Creating industry-wide rules and guidelines also requires dealing with resistance by some firms reluctant to giving up their proprietary ways of doing things that are now excluded by the specifications of the industry-wide standard. These constitutive exclusions of firm-centric forms of operating manifest as *pragmatic tensions* that challenge the adoption and implementation of industry standards. As these tensions largely concern issues of design or deployment, not purpose or value, they are usually addressed through market pressure, normative isomorphism, or education. As we saw in the book industry, early resistance to adopting the standard book identifier was overcome through the strong influence of key stakeholders in the industry.

Second Digital Undertow: Expanding Industry Standards

The second wave of digitalization entails digital decoupling that blurs the boundaries of previously tightly-coupled content, services, and devices, enabling their convergence (Tilson et al. 2010; Yoo et al. 2010a). These processes of decoupling and convergence generate new digital materializations of the products and services structured by existing industry standards. As these standards are based on the prior materializations of tightly coupled content, services, and devices with distinct boundaries, they cannot effectively coordinate and regulate the novel, loosely-coupled, cross-boundary digital phenomena generated by the second wave of digitalization. As the continued constitutive exclusions of these new

digital materializations become significant, they manifest as *tactical tensions* that pressure authorities to revise the standards specifications accordingly.

The expanding of industry standards requires standards work to ensure that the rules and guidelines correspond with the new materializations of digitally decoupled phenomena, a process entailing deliberation and negotiation over the most effective ways to enact the revisions. As with the initial development of industry-wide standards, revision efforts involve the engagement of multiple interested parties and infrastructures (both within and adjacent to an industry) so as to accommodate the requisite enhancements to existing standards without loss of control and flexibility. The widespread use of common interfaces (Hanseth et al. 1996; Hanseth & Lyytinen 2010) allows for changes to be targeted at interface definitions and usage recommendations, thus reducing disruption to the firms relying on the industry standards in their operations. Within the book industry, adoption of barcodes on book covers facilitated automated distribution and sales, but necessitated expansion of the ISBN from 10 to 13-digits to comply with the EAN numbering scheme required for materializing scannable barcodes.

In practice, the ongoing use of the revised industry standards occasionally encounters difficulties on the ground, resulting in problems not covered by the rules and guidelines of the industry standards. The constitutive exclusions of such problematic uses manifest as *pragmatic tensions* that strain everyday operation of the industry standards. These challenges to standards typically involve particular usage issues rather than broad opposition to standards, and as such they tend to be managed locally through focused communication and training efforts, and the influence of powerful players. Within the book industry, for example, some publishers objected to barcodes on aesthetic grounds, but pressure from major retailers quelled this resistance and ISBN barcodes quickly became standard practice across the industry.

Third Digital Undertow: Displacing Industry Standards

The third wave of digitalization entails digital recombining, which creatively repurposes content and processes to generate novel services and products (Henfridsson & Bygstad 2013; Nambisan et al. 2017; Yoo et al. 2010a) that challenge the existing industry standards predicated on phenomena materializing in prior ways. Novel digital materializations of mashed-up products and services now lie outside the

purview of existing industry standards. As these digital recombinations grow in importance and scale (Henfridsson, Nandhakumar, Scarbrough & Panourgias 2018), their continued constitutive exclusions manifest as *tactical tensions* that pressure standards authorities to modify the industry standards so as to include them.

The work of extending industry standards to deal with digital recombinations of products and services produces significant modifications to standards' rules and guidelines. If firms within the industry continue to offer existing services and products in addition to new mashed-up ones, the standards need to include specifications for both the existing phenomena as well as the digital recombinations. Given that existing standards were designed to correspond with the specific materializations of existing phenomena, updating them to also correspond with markedly different novel materializations is extremely difficult, if not infeasible. An entire overhaul and re-specification of the standards from the ground up may be required, involving a lengthy, complex, and expensive project that may face considerable resistance and possible rejection by firms deeply invested in the existing standards.

In the absence of a major redesign, extensions are made to existing standards, but in order to retain continuity with past commitments, these extensions include rules for differentiating established products and services from the novel mashed-up products and services, so as to channel them into separately structured industry operations. These requirements substantially increase the cost and complexity of operations on the ground, leading market participants to bypass the industry standards for many of their novel digital materializations (whether through resistance, non-usage, or exemption). As the size and importance of the digital recombinations grow further (Henfridsson et al. 2018), more and more of the market is constitutively excluded from the industry standards. Manifesting as *existential tensions,* these exclusions challenge the purpose, value, and authority of industry standards that no longer coordinate and regulate the activities, flows, and relations of the whole industry. Given their scale and severity, existential tensions cannot be overcome through industry outreach, market/normative pressures, or localized training. Their continuation leads over time to the displacing of industry standards from widespread use in the industry, unable to operate effectively in an increasingly digital world (see Figure 5).

The result is a bifurcation of the industry with respect to standards. Flowing in one direction, we find established products and services that continue to be effectively coordinated and regulated by existing standards as their materializations remain in correspondence with those standards' rules and guidelines. Flowing in the other direction, we find novel recombinations of products and services that are not coordinated or regulated by existing standards as their digital materializations are either ruled out or not effectively structured by the extensions made to the standards' rules and guidelines. This branching of the industry requires firms to interrogate products and services to assess whether or not they are subject to existing rules and guidelines, and how or not they should participate in industry operations. This requirement to know the details of each product or service a priori compromises the value of common interfaces that had earlier been provided by modular designs and black-boxing of implementation details (Hanseth et al. 1996; Hanseth et al. 2006). The resulting loss of control and flexibility incurs costs, errors. delays, and complexities for firms operating with both established and novel products and services.

Within the book industry, these tensions manifested as the third wave of digitalization digitized the book, requiring revisions to the ISBN rules and guidelines that retained consistency with print books while including novel materializations of digital books. Navigating these different structuring requirements, the extensions to the ISBN rules and guidelines exempted direct-to-device e-books and required distinct ISBNs for multiple digital materializations of each e-book (manifesting different digital publishing formats, different digital rights, etc.). In practice, these changes had far-reaching implications, as the growing number of exempted Kindle e-books and the refusal by many publishers to assign multiple ISBNs to the same content in different digital versions has led to a bifurcation of the market, and the displacing of the ISBN's authority for the coordination and regulation of e-books.

The emergence of digital displacing is a critical albeit unwitting outcome of the digital undertow produced by the third wave of digitalization. Unlike the strategic digital transformation of firms' core business activities (Bharadwaj et al. 2013; Hinings et al. 2018; Vial 2019), which tends to be value creating and highly visible, the digital transformation of industry standards entails slower, subtler, and less visible processes. But the outcomes, particularly with respect to digital displacing, are deeply consequential for an industry. The gradual erosion of existing standards' purpose, value, and authority for

structuring digital phenomena are fragmenting the industry, leaving it without common and robust standards for coordinating and regulating industry-wide activities flows, and relations.

The digital displacing of a standard from everyday use within an industry is not the same as replacing one standard with a better or rival one. On the contrary, it constitutes an existential challenge to the capacity of an existing standard to effectively structure industry operations in the digital age. The process of digital displacing calls into question the possibility of specifying industry-wide standards that can coordinate and regulate the multiple, diverse, and dynamic materializations of digital phenomena generated by recent waves of digitalization. The industry bifurcation we identified in our study may expand and spread, generating further industry branching in numerous directions, each corresponding to distinct digital innovations structured in locally-defined ways, thus forfeiting the possibility of using any common standards for industry-wide operations.

IMPLICATIONS

This research examined how processes of digital transformation affect industry standards over time. Based on the findings of our field study and grounded theorization, we believe that this work offers four important research contributions.

First, we draw attention to a significant but less visible kind of digital transformation at work — the transformation of industry standards as a corollary effect of waves of digitalization. We contribute to the literature on digital transformation by identifying the distinctive conditions and processes that lead to industry standards being unwittingly transformed through digitalization efforts. Much of the digital transformation literature has focused on strategic changes to firms' core processes, services, and products as a result of deploying innovative digital technologies. Our study offers insights into how waves of digitalization necessarily transform industry standards even though those standards are not the specific target of digitalization efforts. Prior research has discussed the unintended consequences routinely produced by technology projects in such terms as side effects, drift, and emergence (Boudreau & Robey 2005; Ciborra et al. 2000; Hanseth et al. 2006; Orlikowski 1996; Scott 2000). We add to these important ideas by theorizing the digital undertow as a corollary effect of digitalization that produces

specific tensions when industry standards lose correspondence with materializations of the phenomena they coordinate and regulate. Our articulation of the processes of the digital undertow contributes a detailed and nuanced understanding of how industry standards are unwittingly transformed by successive digitalization efforts, providing valuable insights and analytical vocabulary for future research.

Second, we contribute to the literature on industry standards by offering a grounded theorization of the relations among waves of digitalization, standards, and intended/unintended consequences. Much of the standards literature has studied the creation, modification, contestation, and decline of industry standards (Busch 2011; Yates & Murphy 2019), but what has not been considered to date is how and why different digitalization efforts affect industry standards. Our research theorizes the relations between industry standards and materializations of the phenomena they structure by distinguishing three tensions that emerge in these relations (tactical, pragmatic, and existential), which pressure standards to accommodate novel materializations of phenomena. In explicating the differences among these tensions, we are able to explain the conditions through which industry standards are promoted and supported by waves of digitalization (when standards are in correspondence with materializations of phenomena they structure), and the conditions through which industry standards are undermined and displaced by digitalization efforts (when standards lose correspondence with materializations of phenomena they structure).

Our identification of the digital displacement of standards' authority and capacity to govern industry-wide activities may have profound implications for relations among digital innovations and standards going forward. Future digitalization efforts may have to contend with boundaries that are made when industries splinter into separate trajectories structured by different (or no) standards that correspond to multiple materializations of digital phenomena. The resulting co-existence of irreconcilable industry standards will generate friction in industry-wide activities, flows, and relations, potentially fracturing industries into distinct communities of code (Mackenzie 2006). More research is needed to examine whether and how digitalization contributes to industry fragmentation and with what consequences.

While standards are a prominent means of structuring industry-wide activities, flows, and relations, they are not the only processes that do so. The concept of apparatus sensitizes us to expect that additional industry structuring mechanisms may be similarly affected as a corollary effect of digitalization, and

might benefit from the kind of theoretical analysis we conducted here. Examples of other structuring mechanisms include exchange agreements (e.g., SWIFT rules for global financial transactions), codes (e.g., IBC international building specifications for health and safety), protocols (e.g., TCP/IP Internet service agreements for packet switched networking), statutes (e.g., SEC requirements for financial reporting), certifications (e.g., Fairtrade provisions for ecological and equitable farming), and accreditations (e.g., FLA labor compliance principles for fair working conditions). To the extent that these mechanisms are entangled with the materializations of the phenomena they structure, then waves of digitalization may also influence and challenge their capacity to act effectively through the processes of the digital undertow we have articulated here.

Third, we contribute to literature on infrastructural digital transformation and the emergent industry ecologies that are produced through enabling and constraining interdependencies. In studies of local-global processes of standardization and platform boundary resources there is substantial interest in understanding how to manage tensions of control and flexibility so as to deal with local demands for adaptability as well as global concerns of consistency and commonality. The widely-held view is that modularization is the answer because black-boxing parts of the infrastructure means that one needs attend only to the interfaces or abstract parameters of the system (Hanseth et al. 1996). Our findings are consistent with this prior work, and support Hanseth et al.'s (2006) argument that a black-boxing strategy works well in conditions of stability but may fail to do so when conditions become instable.

Our study contributes additional insights by identifying the distinctive conditions that contribute to the breakdown of black-boxing in practice. We find that when strategic digitalization efforts transform how core phenomena materialize, the industry standards lose correspondence with the phenomena they are intended to coordinate and regulate, thus excluding novel digital phenomena from their purview. To continue operating, firms have to peer inside the black box to assess whether or not each product and service should be structured by the existing standards, incurring cost, confusion, and complexity. The resulting instability engenders an existential challenge to industry standards that threatens their purpose and value, displacing them as the primary structuring authority for industry operations in the digital age. By examining relations between digitalization efforts and changes in standards, we provide an alternative

way of examining infrastructural tensions in practice. By focusing on when and how continuities and discontinuities in standards are enacted in practice, we highlight the constitutive exclusions that are marked out by the discontinuities and which manifest as specific tensions on the ground. Constitutive exclusions offer important insights into when conditions might shift from relative stability to instability. As we found, when constitutive exclusions prove particularly severe and large scale, they can significantly undermine the effective operation of structuring mechanisms in an industry.

Fourth, the historical approach adopted in this study provides a detailed articulation of how, over time, processes of the digital undertow have produced generational reconfigurations with long term industry-level implications. Our genealogical investigation offers a valuable analytical approach entailing diagnosis and problematization, which guides the effort involved in deconstructing 'how we got here' by inquiring into the conditions of possibility that have produced the present-day issues. We believe this analytical approach is particularly helpful in explaining how and why waves of digitalization generated the conditions for developing and expanding an authoritative industry-wide standard, and the conditions for displacing it from widespread use. We suggest that a genealogical approach can provide a powerful way to explore complex and puzzling challenges evident in the present, challenges that in contemporary society are inextricably bound up with ongoing processes of digitalization and their intended and unintended outcomes.

We encourage future studies of digital transformation to include research into the corollary transformation of industry standards that are integral to industry operations, and to call out the constitutive exclusions that give momentum to processes of the digital undertow. In so doing, we hope to inspire a further agenda exploring the ongoing dynamics of the digital undertow and how these shape industries over time. Inseparable from waves of digitalization, the digital undertow is constitutive of the conditions of possibility produced, and thus critical to the generativity and challenge of digital transformation.

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Table 1: Number and Type of Interviews and Events (in Total and related to Standards)

Interviews	Details	Total	Standards
Publishers	Trade publishers	32	17
	Scholarly publishers	23	12
Providers	Retailers; Online content providers	10	4
Industry Standards Bodies	Standards experts; Agents	8	8
Industry Professionals	Consultants; Strategists; Researchers	13	4
Industry Services	Information analysts; Bibliographic agencies	20	5
Libraries	University librarians; Public librarians	19	6
	Number of Interviews	**125**	**56**

Events	Details	Total	Standards
Industry Conferences	Frankfurt Book Fair; The Bookseller Childrens' Conference	5	3
Specialist Conferences	EDItEUR Supply Chain Seminar; BISG Metadata Summits; BIC Meeting on THEMA	5	5
Training Courses	BISG webinars on ISBN and Identifiers; BISG Training for ONIX; Publisher Metadata Workshop	4	4
	Number of Events	**14**	**12**

Table 2: Tensions with the ISBN Standard Related to Early Waves of Digitalization (pre-2007)

Early Waves of Digitalization	Digital Innovations	ISBN Specifications for Books	Emerging Tensions	Examples from the Field
Digitizing supply chain processes	Warehouse automation and electronic distribution	ISBN created to provide standard book identifier, enabling industry efficiencies and growth in the global book trade	Resistance	"There were publishers who said, "Why can't I reuse my numbers for other titles? I've sold all of the previous edition." We had to introduce them to the concept of books having a rather longer shelf life than they'd previously conceived of." (UK Standards Expert)
			Usage Problems	"In the early days … ISBNs had a whole bunch of, you know, nonstandard practices. There wasn't agreement in the last decade about how to use ISBNs, so all kinds of problems popped up." (Industry Consultant)
Digitizing retail processes and industry information services	Barcodes and electronic points of sales	ISBN revised to support industry-wide operations and provide market-level insights, trends, and intelligibility	Resistance	Publishers believed that barcodes "ruined the aesthetic of the book." (Industry Commentator)
			Usage Problems	"For people like us who work with the title information you would never use the ISBN to identify the title in any event as it is notoriously unreliable (data entry issues at some point in the chain usually) and obviously with a database then needs to create relationships to other information in the publishing process (print estimates; rights contracts; royalties etc. etc.) you would have to have a unique unmodifiable identifier for the purposes of ensuring you could do so." (Bibliographic Analyst)

Table 3: Tensions with the ISBN Standard Related to Third Wave of Digitalization (post-2007)

Third Wave of Digitalization	Digital Innovations	ISBN Specifications for *Digital* Books	Current Tensions	Examples from the Field
Digitizing Book Products	Digital files in multiple formats rendering on a variety of electronic devices and computers	Each digital book in the supply chain with a different digital format and/or usage restriction requires a separate ISBN	Resistance	"People haven't really adopted this best practice of giving each e-book product a separate ISBN. But then that causes you problems if there are differences between the products because you can't differentiate among them." (Publisher)
				"It's pretty common to have two, or three or five ISBNs for different varieties of an e-book, which have the same content. Not every publisher follows those rules. Not even every mainstream publisher follows those rules." (ISO committee member)
				"[T]here's a significant split in the industry about whether each format of a digital product should have a unique identifier or not … And there will be times when people want to know, you know, what format is more popular, and if they don't divide it to that level, the industry will never know. And it's always best to go as granular as possible. … [When] we talk to the industry they go, 'But it adds cost to my process, and I don't want to do it like that because the only little bit of difference is the format in which it is in. I don't want to use a unique identifier for each one.' And so, there's a tension there." (Information Analyst)
	Unbundled and customizable digital content	No rules specified, so existing ones apply: each distinct tradeable object in the supply chain requires a separate ISBN	Usage Ambiguity	"As we allow customers to put together their own 'book' made up of chapters from other titles across many publishers, those custom titles may become separately tradeable. … The logical conclusion here is mind boggling." (Publisher)
				"Not only are publishers combining different content elements (in addition to text) into 'books,' they are beginning to redefine how books are created. … As a consequence, some publishers openly question the need for an ISBN as their future publishing programs develop." (Industry Consultant)
	Digital books sold within vertically integrated and proprietary systems	Kindle books do not require ISBNs because they are sold directly to consumers and do not enter the supply chain	Non-Usage	"We are experiencing some strain within the ISBN, for example, because it is such a mature standard. Self-published authors, who really have no need for the ISBN because they're publishing strictly through Amazon, and Amazon does not require ISBNs, they're publishing purely digitally so there's no physical component to put the ISBN on. So, that's a definite pain point." (Industry Consultant)
				"A lot of authors can choose not to use ISBNs because no e-book platform requires them. So there's a lot of stuff out there on the market that we have no way of tracking. And we don't even know how big the market is." (Industry Consultant)

Figure 1: Waves of Digitalization and the Digital Undertow
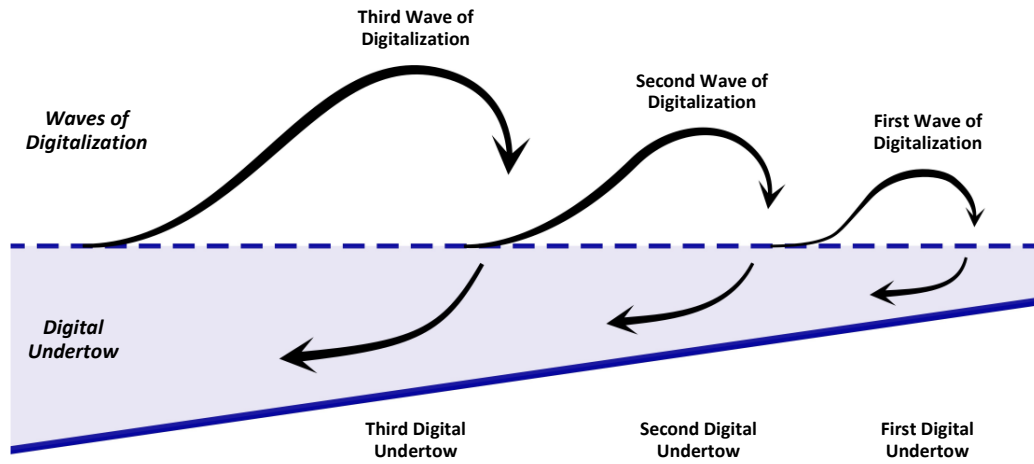
Figure 3: Example of an ISBN Barcode[6]

ISBN 13: 978-1-4214-2889-5
ISBN 10: 1-4214-2889-X

9 781421 428895

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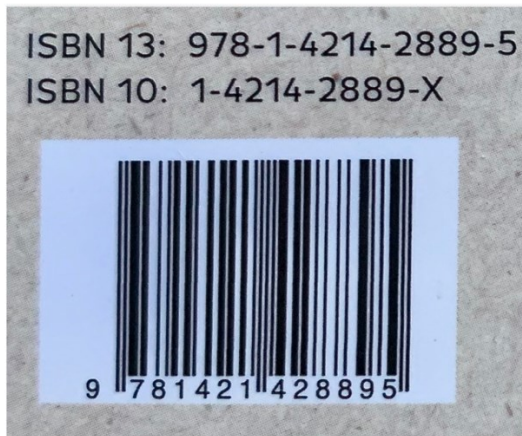
[6] From the back cover of Yates & Murphy (2019).

Figure 2: Continuities and Discontinuities in ISBN Usage within the Book Industry over Time

Third Wave of Digitalization
(digitizing products)

Second Wave of Digitalization
(digitizing services)

First Wave of Digitalization
(digitizing processes)

Pre-digitalization

2020s — ISBN used for most print books | Kindle eBooks grow and include self-published books; ISBN is not required

2010s — ISBN used for most print books | Kindle eBooks grow; ISBN is not required

Mid-2000s — ISBN used for most print books | Kindle eBooks emerge; ISBN is not required

Late 1990s — ISBN used for most books; online sales of print books emerges

Early 1990s — ISBN is the dominant standard in the global book industry used for most books

1980s — ISBN is adopted by much of the global book industry

1970s — Firm specific identifiers continue in some countries | ISBN approved as international standard book identifier

Late 1960s — Firm specific identifiers continue outside of the UK | SBN adopted by the UK book industry

Mid-1960s — Firm specific identifiers continue in most of the global industry

Pre-1965 — No standard identifier in global book industry; firm specific identifiers proliferate

Other eBook formats/devices use ISBN inappropriately

Other eBook formats/devices use ISBN consistently

SBN emerges within UK retailer, WH Smith

Legend:

- Inconsistent, firm-specific identification practices in the supply chain
- Consistent identification practices in the supply chain (based on SBN or ISBN)
- Proprietary identification practices in online platforms (mainly Amazon)

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Figure 4: Theorizing How Digital Transformation Affects Industry Standards

Figure 5: Digital Displacement of Industry Standards

Third wave of digitalization digitizes core phenomena of the industry

Tactical Tensions

industry standards are pressured to adapt in response to digitized phenomena whose novel materializations do not correspond with existing rules and guidelines

Existing rules and guidelines of industry standards are extended to accommodate digital materializations of core phenomena
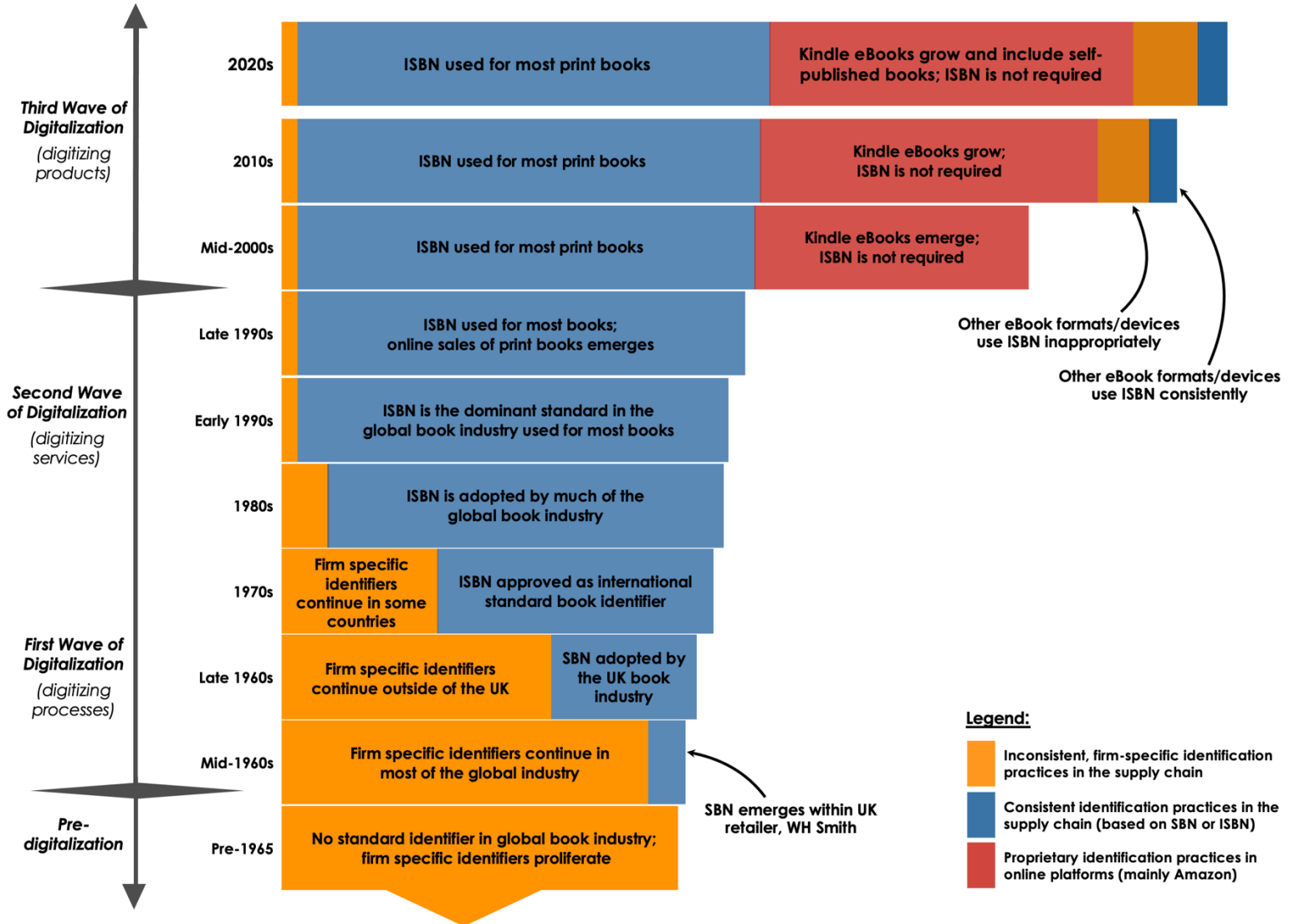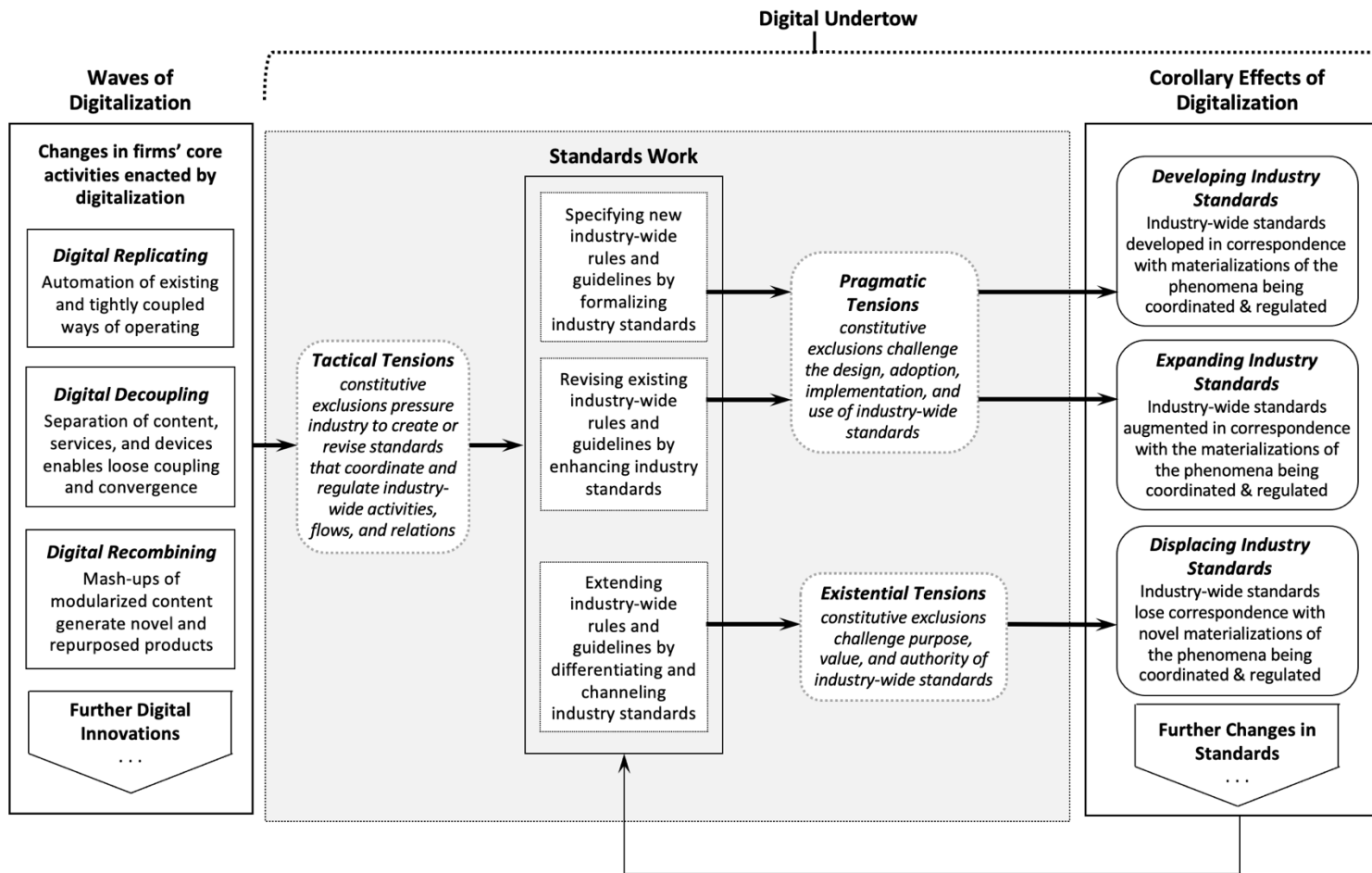
Existential Tensions

resistance, usage ambiguity, and non-usage of extended industry standards

Digital Displacement

- digital phenomena are exempted from or not well accommodated by the extended rules and guidelines of the industry standards

- industry bi-furcates as digital phenomena overflow capacity of industry standards to coordinate & regulate them

- industry standards lose their authority to coordinate & regulate industry-wide activities, flows, and relations

Existing phenomena continue to be effectively coordinated and regulated as their materializations remain in correspondence with rules and guidelines of industry standards

Digital phenomena are excluded from industry-wide processes as their novel materializations are not effectively coordinated and regulated by the extended rules and guidelines of the industry standards