Understanding Ambidexterity: Managing Contradictory Tensions Between Exploration and Exploitation in the Evolution of Digital Infrastructure

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Abstract

Prior research on the evolution of digital infrastructure has paid considerable attention to effective strategies for resolving contradictory tensions, yet what we still do not understand is the role of higher-level organizational capabilities that help balance the contradictory tensions that emerge during this evolution. In addressing this gap, two related questions guided our investigation: (1) How do organizations experience and resolve contradictory tensions throughout the evolution of digital infrastructure? and (2) What can we learn about the organizational capabilities that drive strategic actions in resolving these contradictory tensions? We approach these questions using an in-depth case study at RE/MAX LLC, a global real estate franchise. Based on our findings, we propose a theoretical model of digital infrastructure ambidexterity. The model recognizes three pairs of capabilities (*identifying* and *germinating*, *expanding* and *legitimizing*, and *augmenting* and *implanting*) and two supporting factors (*leadership* and *structure*) that are key to resolving contradictory tensions during this evolution. This study responds to a recent research call for dynamic process perspectives at multiple levels of analysis. We discuss the implications of this model for research and practice and offer observations for future research.

Keywords: Digital Infrastructure Evolution, Organizational Capabilities, Contradictory Tensions, Ambidexterity, Exploration and Exploitation, Case Study, Qualitative Research, Real Estate Industry.

1 Introduction

Digital infrastructures have been defined as shared, unbounded, heterogeneous, open, and evolving sociotechnical systems that comprise diverse IT capabilities and their use, operations, and design communities (Braa et al., 2007; Hanseth & Lyytinen, 2010). They take a long time to build—very often spanning decades rather than a few years (Tilson, Lyytinen, & Sørensen, 2010; they require substantial financial investment and careful coordination of the standards that define key interfaces and behaviors

(Star, 2002); and they are also path-dependent—creating further resistance to change (David, 1985). In other words, digital infrastructures *evolve*.

The challenges faced in the process of digital infrastructure evolution has often been acknowledged in prior literature as being contradictory in nature. In other words, the evolution of digital infrastructure often encounters *tensions* that are *contradictory* to each other. Building on prior research, here we define contradiction as "bipolar opposites that are mutually exclusive and interdepend such that the opposites define and potentially negate each other" (Putman,

Fairhurst, & Banghart, 2016, p. 70) and we define tension as "stress, anxiety, discomfort, or tightness in making choices, responding to, and moving forward in organizational situations" (p. 69). In prior literature, digital infrastructures are seen to be:

- Stable (supporting existing processes and actors), but also flexible (allowing unbounded growth) (Henningson & Henriksen, 2011; Tilson, Lyytinen, & Sørensen, 2010).

- Aligned with various standard organizational processes, but also with nonstandard structures and practices of the organization (Gal, Lyytinen, & Yoo, 2008; Monteiro et al., 2013).

- Enforcing best practices, but also remaining diverse and malleable (Scott & Wagner, 2003).

- Linked to the need for and ability of organizations to tighten (centralize) and exert control, but also allowing scope for autonomy and loosening of control (Bharadwaj et al., 2013; Rodon & Silva, 2015).

- Providing the capacity to embrace, adapt, and access a range of tasks, but at the same time constrained by prior investments, designs, decisions, and associated forms of control (Brynjolfsson & Saunders, 2009; Hanseth 2000).

Existing literature has paid considerable attention to specific strategies that have proven to be effective in resolving contradictory tensions (such as adaptability, bootstrapping, decentralization, causal mechanisms, governance models, and loosely coupled architectures), which may impact successful infrastructure evolution (Braa et al., 2007; Bygstad, 2013; Hanseth & Lyytinen, 2010; Henfridsson and Bygstad 2013; Rodon & Silva 2015). In spite of this attention, one cannot but wonder: Are we somehow missing the forest for the trees? That is, while prior research has paid attention to strategic actions, focusing overtly on such actions may hinder theoretical progress by keeping us from recognizing the higher-level capabilities that enable organizations to address the contradictory tensions that arise as the digital infrastructure evolves (Tilson, Lyytinen, & Sørensen, 2010). As O'Reilly and Tushman (2008, p. 8) note, "what is missing is a clear articulation of those specific capabilities that facilitate exploration and exploitation". In other words, as digital infrastructures evolve, the challenges that emerge through this evolution process are dynamic and may not be redressed by focusing on strategic actions alone. While the efficacy of the strategic actions is no doubt important, what else can we learn and articulate about the higher-level organizational capabilities that may drive these strategic actions?

We argue here that central to the evolution of a digital infrastructure is the organizational capability to continuously identify and resolve contradictory tensions. This ability of organizations to attend to and deal with competing tensions simultaneously is referred to as "ambidexterity" (March, 1991). Our purpose in this paper is therefore to shed light on the interrelated concepts of contradictory tensions and ambidexterity during the evolution of a digital infrastructure. More specifically, our examination focuses on two related research questions: (1) *How do organizations experience and resolve contradictory tensions throughout the evolution of digital infrastructure?* and (2) *What can we learn about the organizational capabilities that drive strategic actions in resolving these contradictory tensions?* We approach our research questions through an in-depth case study of RE/MAX, a global real estate franchise, and its efforts to establish a digital infrastructure to support its associates. In doing so, we present one of the first in-depth studies of ambidexterity embracing various levels of the organization over time. The digital infrastructure, called MainStreet, evolved from a stand-alone corporate extranet to a fully integrated agent- and broker-driven resource center that allows user customization (see the Appendix for a detailed description).

Based on analysis of the rich field data, this study's contribution is in articulating the concept of digital infrastructure ambidexterity and proposing its underlying theoretical model. The model identifies three pairs of capabilities (*identifying* and *germinating*, *expanding* and *legitimizing*, and *augmenting* and *implanting*), supporting leadership (at the *top*, *middle*, and *operational* levels), and supporting structures (*differentiated, independent*, and *integrated*) that enable the ambidexterity that allows the organization to attend to contradictory tensions in the evolution of digital infrastructure (in *initiating*, *cultivating*, and *growing* phases). The theoretical model that we advance here has integrative value because it weaves together previously dispersed findings and offers a more nuanced perspective of the role of organizational capabilities, leadership, and structures in managing the evolution of a digital infrastructure.

The paper is structured as follows. First, drawing on existing research on digital infrastructure evolution, contradictory tensions, and organizational ambidexterity, we introduce the concept of digital infrastructure ambidexterity. Second, we briefly describe the research setting and our data collection procedures. Next, to address our first research question we provide the case description that articulates how RE/MAX experienced and resolved contradictory tensions during the evolution of its digital infrastructure. In Section 5 (Analysis and Theoretical Integration), we address our second research question

by structuring our findings around four theoretical themes that we identified in the evolution of the digital infrastructure that took place at RE/MAX. In Section 6 (Discussion), we advance a theoretical model that recognizes the capabilities that underlie the resolution of contradictory tensions and offer observations for future research. Finally, we discuss the implications of this study for research and practice and present our conclusions.

2   Theoretical Background

2.1   Digital Infrastructure Evolution

Digital infrastructure evolution has been defined as an ongoing, complex, and dynamic process of interweaving sociotechnical arrangements that go beyond the scope of a single system or technology (Yoo, Henfridsson, & Lyytinen, 2010; Henfridsson & Bygstad, 2013). Over the past 15 years, we have observed the evolution of digital infrastructures covering different settings (e.g., health, telecom, banking, natural resources, government, and manufacturing), levels of analysis (e.g., group, organization, industry, and society), and technologies (e.g., the Internet, World Wide Web, and electrical grids). Only recently, however, has IS research begun to focus on the impact of the one class of IT artifacts—digital infrastructures—that underlie digital convergence (Tilson, Lyytinen, & Sørensen, 2010, p. 748). Tilson, Lyytinen, and Sørensen's (2010) study analyzes all the papers published in *Information Systems Research* during the first 20 years of the journal and finds that a mere 2 percent of them were attentive to infrastructure issues. The study also finds only five papers with infrastructure issues as their primary focus, including the groundbreaking analysis of the evolution of digital research infrastructure by the late Star and Ruhleder (1996). The same authors also conducted a similar review of *MISQ*, with similar results (Tilson, Lyytinen, & Sørensen, 2010). More recently, the number of special issues and publications on digital infrastructure in top IS journals suggests the topic is attracting growing attention (Ellingsen & Bjørn, 2014; Gregory et al., 2015; Monteiro, Pollock, & Williams, 2014; Rodon & Silva, 2015).

The emerging stream of literature has advanced the idea that digital infrastructure evolution entails both social and technical elements (Vaast & Walsham, 2009). Infrastructures often evolve into larger and more complex structures without any predefined end state, as they are continuously being extended and typically operate outside the control of a single stakeholder. Greenbaum and Kyng (1991) propose the

notion of "continuing design in use" to capture the practical kinds of reworking necessary to get information technologies to function within a particular organizational setting. Karasti, Baker, and Halkola (2010) coin the term "continuing design" to refer to a "development orientation where the relationship between short-term and long-term—traditionally seen as a tension—is addressed and accounted for from the point of view of infrastructure time by incorporating it as a foundational design consideration" (p. 247). Such reorientation is necessary because digital infrastructures (that may last for decades) evolve over different timescales than traditional IT projects (which operate over periods of one to three years). Edwards et al. (2007) suggest using a metaphor of "growing"—rather than designing or building—infrastructures to capture the "sense of an organic unfolding within an existing (and changing) environment" (p. 369). This study reveals that within infrastructures there is a "recurring issue of adjustment in which infrastructures adapt to, reshape, or even internalize elements of their environment in the process of growth and entrenchment" (p. 360). Ribes and Finholt (2009) observe that those trying to initiate, promote, and grow infrastructures need to integrate the "demands of the present" with those imagined as likely to be important in "the future"—what Braudel (1949) describes as the "long now". Infrastructure evolution thus requires the organization to be able to manage, coordinate, and prioritize work on many fronts. Yet, we still do not understand how organizations experience and resolve contradictory tensions throughout the evolution of digital infrastructures.

2.2   Contradictory Tensions in the Evolution of Digital Infrastructure

The evolution of digital infrastructure entails contradictory tensions (and the related terms dualism, paradox, dilemma, and dialectic). Handy (1994) notes that the phrase, "it's a paradox", has become a management cliché for describing opposing forces in complex organizational environments. For Handy, the phrase is overused and underspecified, but it typifies the fact that contradictions are the "new normal" in this volatile, rapidly changing landscape of organizations.[1] Prior research on digital infrastructure evolution has highlighted its complexity, which frequently translates into tensions related to goals and priorities and contradictory demands in terms of what these infrastructures should do and achieve (Jiang et al., 2014; Ribes & Finholt, 2009; Ribbers & Schoo, 2002; Weill & Ross, 2009). Karasti, Baker, and Halkola (2006), for example, underscore the importance of understanding the "unavoidable tensions and conflicts"

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[1] For recent definitions and comparisons of the various types of contradictory tensions (such as paradoxes, dualisms, dilemmas, and contradictions), see Putman, Fairhurst, and Banghart (2016).

that occur when "balancing multiple frames or local-global options" (p. 352). Furthermore, Ford and Backoff (1988) suggest that infrastructures appear stable only when oppositional tendencies are brought into recognizable proximity through reflection or interaction.

Existing literature has paid considerable attention to strategies that have proven to be effective in resolving contradictory tensions in infrastructure evolution. Such strategies include, for example, adaptability (Hanseth & Lyytinen, 2010), bootstrapping (Hanseth & Aanestad, 2003; Hanseth & Lyytinen, 2010), decentralization (Broadbent, Weill, & St.Clair, 1999; Ciborra et al., 2000), flexibility (Braa et al., 2007; Hanseth, Monteiro, & Hatling, 1996), generativity (Bygstad, 2010; Henfridsson & Bygstad, 2013; Silsand & Ellingsen, 2014), grafting—merging technological innovations into existing sociotechnical arrangements—(Sanner, Manda, & Nielsen, 2014). Other strategies include using governance models (Ure et al., 2009), loosely coupled architecture (Fabri, 2008), mobilization (Aanestad & Jensen, 2011), and stratification and meshworking (Rodon & Silva, 2015). These strategies are abstractions that take the form of descriptive patterns and self-reinforcing mechanisms that produce observable events. This stream of research has been useful not only in identifying specific strategies that influence the design of digital infrastructures, but also, and more importantly, in establishing the ontological grounding and analytical language to enable us to understand infrastructure evolution (Monteiro, Pollock, & Williams, 2014). This research stream has not, however, explained the role of organizational capabilities in balancing the contradictory tensions that emerge during this evolution.

2.3 Contradictory Tensions and Organizational Ambidexterity

By resolving contradictory tensions, managers contribute to an organization's ability to pursue disparate activities simultaneously, which is the focus of ambidexterity (Gibson & Birkinshaw, 2004). Organizational ambidexterity is the ability of an organization to manage both incremental, continuous improvements and radical, discontinuous challenges at the same time (Tushman & O'Reilly 1996). Ambidexterity research has acknowledged that the concepts of contradictory tensions and ambidexterity are closely interrelated and should be viewed in combination (Smith & Lewis, 2011; Gregory et al., 2015). In fact, Smith and Lewis (2011) observe that "Recent ambidexterity research has adopted a paradox lens, stressing that overall organizational success depends on exploring and exploiting simultaneously" (p. 388). Since digital infrastructure evolution entails managing contradictory and competing imperatives, we argue here that the theoretical integration of contradictory tensions and ambidexterity is highly

suited to studying contradictory demands during digital infrastructure evolution.

Organizational ambidexterity has been conceptualized as a dynamic capability based on the insight that achieving organizational ambidexterity may involve sensing environmental threats, seizing opportunities, and dynamically reconfiguring resources accordingly (Birkinshaw, Zimmermann, & Raisch, 2016; O'Reilly & Tushman, 2008). Furthermore, ambidexterity has frequently been referred to as the balancing of exploration and exploitation (Raisch et al., 2009). The conceptual distinction between exploration and exploitation has been studied intensively in various disciplines (Adler, Goldoftas, & Levine, 1999; He & Wong, 2004) and is a common theme in the strategic management literature (Jansen et al., 2008; Levinthal & March, 1993; Smith & Tushman, 2005).

Exploration is defined as activities that increase variation by creating new possibilities in the future. According to March (1991), exploration is associated with activities such as innovation and discovering new opportunities. On the other hand, exploitation is characterized by routine activities that enhance efficiency and discipline at the firm and help develop continuous problem-solving procedures (Smith & Tushman, 2005). Exploitation involves improvements in production, efficiency, and implementation. Managing exploration and exploitation simultaneously, however, is not an easy task because each is associated with fundamentally different organizational architectures, processes, competencies, and logic (Floyd & Lane, 2000; Smith & Tushman, 2005). Levinthal and March (1993) argue:

> The basic problem confronting an organization is to engage in sufficient exploitation to ensure its current viability and, at the same time, to devote enough energy to exploration to ensure its future viability. Survival requires a balance, and the precise mix of exploitation and exploration that is optimal is hard to specify (p. 105).

In IS research, the emphasis of ambidexterity research has been on the dichotomy between exploration and exploitation (Xue, Ray, & Sambamurthy, 2012). Companies that focus on exploitation and exclude exploration, elicit short-term advantage of the technology, maintain a state of stable equilibrium, and extract as much value as possible, and as soon as possible, from the IT investment—especially if this involves a large-scale, multiyear IT investment or significant managerial effort. Focusing exclusively on exploitation, however, has been found to result in excessive automation, routinization, simplification, and core rigidities, hurting agility by limiting a firm's strategic choices (Bharadwaj, 2000; Henderson & Clark, 1990;

Sanchez, 1995) and its ability to respond to changes (Ahuja & Lampert, 2001; Leonard-Barton, 1992).

Conversely, engaging in exploration and excluding exploitation may enhance firms' ability for renewal by searching for potentially disruptive ways of using IT to create change proactively rather than reacting to it. Researchers have recommended that, when adopting a new IT system, companies should innovate and improvise with the local working environment (Orlikowski, 1996) and tailor their IT and processes to reflect changing organizational circumstances and requirements. Too much exploration, however, can trap companies in an endless cycle of search and unrewarding change (Volberda & Lewin, 2003).

More recently, IS researchers have recognized that both exploration and exploitation are needed. The organizational ambidexterity perspective has been adopted to explain the complementary and substitute roles of formal and informal controls in outsourced systems development projects (Tiwana, 2010), healthcare innovations (Tarafdar & Gordon, 2007), and the coexistence of agile and traditional software development approaches (Vinekar, Slinkman, & Nerur, 2006). It has also been used to explain the need to exploit software products in relation to existing customers while simultaneously exploring new technology and market opportunities (Napier, Mathiassen, & Robey, 2010), knowledge sharing in long-term relationships (Im & Rai, 2008), and typologies of IS strategies (Chen, Mocker, & Preston, 2010; Leidner, Lo, & Preston, 2011; Lo & Leidner, 2012). Other studies have used organizational ambidexterity to examine the interrelationships between IT-enabled practices and practitioners within an ongoing praxis (Huang et al., 2014) and the transformation of IS strategy during mergers (Gregory, Keil, & Muntermann, 2012; Gregory et al., 2015).

This stream of research, however, has followed the tendency of general organizational ambidexterity research to focus on one organizational attribute at a time to explain ambidexterity—for example, dual structures (Bernner & Tushman, 2003; Tushman & O'Reilly, 1997), organizational contexts that encourage behavioral ambidexterity (Gibson & Birkinshaw, 2004), or the behavior of top management teams (Lubatkin et al., 2006; Smith & Tushman, 2005; Simsek et al., 2005). Overall, the current research has drawn attention to a limited set of features that all ambidextrous organizations seem to have when balancing exploration and exploitation activities, including differentiated organizational structure, tight or loose corporate culture, common values across the firm, and top managers who integrate different units and values across the firm. As Gupta, Smith, and Shalley (2006, p. 697) warn, "although near consensus exists on the need for balance [of exploitation and exploration] to achieve sustainable competitive advantage, there is considerably less clarity on how this balance can be achieved".

Clear exceptions to the above are the studies by Zimmermann, Raisch, and Birkinshaw, (2015), Im and Rai (2008), and Gregory et al. (2015), which explicitly examine ambidexterity dynamically. Zimmermann, Raisch, and Birkinshaw (2015) examine the process by which ambidexterity is initiated, using an inductive multilevel case study of four alliances, and find that a top-down process of charter definition can be complemented with a bottom-up process in which frontline managers take the initiative to adopt an ambidextrous orientation in their part of the organization. In analyzing ambidexterity in IT supply chain relationships, Im and Rai (2008) find that a balance between strategic exploratory and exploitative knowledge sharing is needed. Gregory et al. (2015) use grounded theory methodology and a multiyear case study approach to examine a large IT transformation program in a major commercial bank and identify interrelated themes of paradoxes and ambidexterity. Here we add to this stream of research by focusing on important aspects that have been ignored—i.e., temporality and multiple levels of the organization.

2.4 Digital Infrastructure

Drawing on the literature on digital infrastructures, contradictory tensions, and ambidexterity, we introduce the concept of "digital infrastructure ambidexterity". We define this concept as the ability to continuously and dynamically balance exploration and exploitation activities in order to deal with contradictory tensions during the evolution of a digital infrastructure. Digital infrastructure ambidexterity is a dynamic capability—a direct consequence of dynamic decision-making activities in *temporally* orchestrating resources (Birkinshaw, Zimmermann, & Raisch, 2016; O'Reilly & Tushman, 2008, 2013; Raisch et al., 2009) as the digital infrastructure evolves. As the dynamic capabilities view has attracted more attention, some authors began identifying and explaining the mechanisms by which firms' dynamic capabilities adapt to environmental and technological changes (Birkinshaw, Zimmermann, & Raisch, 2016; Eisenhardt & Martin, 2000; Helfat, 2000; Zollo & Winter, 2002). In particular, *leadership* and *structures* have been identified by prior research as critical supporting factors for organizational ambidexterity. Pertaining to leadership, Augier and Teece (2009, p. 417) recognize that "in the dynamic capabilities framework, management plays distinctive roles in selecting and/or developing routines, making investment choices, and in orchestrating non-tradable assets to achieve efficiencies and appropriate returns from innovations". Structures are organizational mechanisms for recombining and reconfiguring assets and for allocating, coordinating, and supervising tasks

"as the enterprise grows, and as markets and technologies change" (Teece, Pisano, & Shuen, 1997, p. 1335). While we acknowledge that there might be other factors that support ambidexterity, here we focus on factors that have been identified in IS research as having a critical role (Bharadwaj, 2000; Mata, Fuerst, & Barney, 1995; Peppard & Ward, 2004). Thus, in this study, we examine the evolution of a digital infrastructure at RE/MAX as part of our effort to construct a theoretical model of digital infrastructure ambidexterity. We scrutinize the salient contradictory tensions (whether these be dualisms, paradoxes, or dilemmas) that were experienced, and examine how these tensions were handled over time by the organization (i.e., what the capabilities and supporting leadership and structures were used at various organizational levels).

3 Research Approach and Setting

Given that understanding contradictory tensions in the digital infrastructure evolution is a novel phenomenon, and little is known, in general, about how ambidexterity transpires, we selected an in-depth case study research approach. The exploratory and qualitative nature of the research questions (Benbasat, Goldstein, & Mead, 1987)—"How" do organizations experience and resolve contradictory tensions throughout the evolution of digital infrastructure? and "What" can we learn about the organizational capabilities that drive strategic actions in resolving these contradictory tensions?—led us to use an in-depth case study, or what has been termed a "revelatory case" (Yin, 1994). This approach allowed us to capture rich details of the evolution of the digital infrastructure and focus on the salient tensions as well as the capabilities and supporting factors associated with organizational ambidexterity (Birkinshaw, Zimmermann, & Raisch, 2016) in a "real-world" setting.

Our site selection followed Patton's (1990) suggestion that "information-rich cases are those from which one can learn a great deal about issues of central importance for the purpose of the research" (p. 169). Using this criterion, we selected RE/MAX, a leading global real estate franchise firm, as a suitable research setting for our research. We acquired long-term involvement and access to fine-grained, longitudinal data about the firm's launch and evolution over time. The contemporary nature of this case meant that we had access to extensive documentation and that key actors were available for interview.

3.1 Data Collection

The specific research questions formulated in the introduction to this paper guided the data collection process, while what emerged from the data through theoretical conceptualization shaped our understanding (Glaser, 1978). In accordance with Eisenhardt (1989), we reviewed the existing literature on digital infrastructure and ambidexterity to "specify some potentially important variables" and avoided "thinking about specific relationships between variables and theories as much as possible, especially at the outset of the process" (p. 536). We conducted field research (on-site observation, interviews, and documentation review) over the course of 16 months (March 2010 to June 2011). The advantage of this multisourced data was that retrospective data provided more observations, while real-time data helped us to mitigate retrospective bias (Miller, 1997). Furthermore, collecting multiple types of data from different sources provided triangulation and increased the reliability of the study.

The research began with formal meetings with the RE/MAX top management team. These meetings were complemented by the research team visiting the headquarters offices and subsequently conducting face-to-face interviews. To ensure that the data came from all levels of RE/MAX, we conducted 29 interviews with individuals who were identified as being involved in the evolution of MainStreet, RE/MAX's digital infrastructure. These included interviews with top and middle managers at RE/MAX headquarters, owners of RE/MAX affiliates, real estate brokers, real estate agents, IT department personnel, and external consultants (see Table 1 for job designations). In selecting our interviewees, we also took into consideration our previous interviews and views conveyed through secondary materials or notes from our own field observations, as advised by Glaser and Strauss (1967). To secure an independent, objective position in the field (Pratt, 2009), we contacted these informants ourselves and solicited their support for our research project. The corporate management kept their distance and acted primarily as a sponsor of our overall project. We tailored semistructured interviews to each person, focusing on a brief history of the interviewee's involvement with the firm, their perceptions of events that transpired, and why/how decisions and activities were influenced and made, and how conflicts were resolved. The interviews were recorded and transcribed, and additional observations were noted at the time of the interview. To minimize bias and increase the study's reliability, we followed the guidance on retrospective interviewing techniques suggested by Golden (1992) and Miller (1997); this included using multiple knowledgeable informants, asking informants to recall simple facts or concrete events rather than past opinions or beliefs, ensuring confidentiality, minimizing the duration and inconvenience of data collection, and explaining the usefulness of the topic. At least two of the researchers were present in all interviews—one researcher asked questions, while the other listened, took notes, and asked for clarification as

required. This made it possible for us to discuss each interview in detail and to compare notes and interpretations. At the end of each interview, we asked the interviewee to suggest other individuals who would be potential sources for helping us understand the evolution of MainStreet at RE/MAX.

Written data included both primary sources (annual reports, firm archival analyses, organizational charts,

strategic information systems documents, and internal correspondence and memos) and secondary sources (real estate industry reports, trade magazines, newspapers, and relevant published books). Although many of the documents we collected were confidential, they served to confirm or disconfirm interpretations made throughout the data analysis process.

Table 1. Source of the Interviews Conducted

Reference	Area/Role	Duration (minutes)
1	VP IT	92
2	CEO, CFO	75
3	CFO, SVP IT, VP eBusiness	78
4	MainStreet product manager and MainStreet product analyst	65
5	Web developer	67
6	Senior manager, application development	69
7	Senior Manager, product strategy	72
8	Data analyst	69
9	VP eBusiness	86
10	MainStreet, product manager	81
11	BDA consulting	79
12	Senior manager, eCare	72
13	Director, production services, media & training	66
14	Director, RE/MAX University	82
15	VP education, media, & training	68
16	Senior VP eBusines and emerging technologies	85
17	Executive director, membership services/contracts,	89
18	Senior manager, technology training, ebusiness	77
20	Broker/owner RE/MAX professionals	75
21	MainStreet product manager	69
22	Membership database manager	62
23	VP/Regional director	71
24	VP/Regional director central/northern Ohio	77
25	VP/Regional director Carolinas region	63
26	Broker/Owner	79
27	Agent 1	64
28	Broker manager/Owner	82
29	Agent 2	75

Furthermore, throughout this investigation, we had access to the online community of RE/MAX agents. We also attended a two-day forum for MainStreet's users, developers, and technology partners and vendors at RE/MAX. Observational notes, which we took during all of the visits, included numerous references to changes in how people viewed MainStreet over time, including how concerns shifted, reactions varied, and how perceptions were both similar and diverse. In addition, throughout the data collection, we had the advantage of access to the senior vice president of emerging technologies, a key informant, who granted us several interviews. In total, this research study generated a database containing approximately 35 hours of recorded interviews, 50 pages of observational notes, 394 pages of transcribed interviews (215,536 words), and over 2,500 pages of secondary documentation.

3.2 Data Collection

Given the nature of the process data from this study, we combined several strategies for sensemaking, as suggested by Langley (1999) and Langley et al. (2013), moving back and forth between the data and theoretical conceptualization. First, during the data collection, notes on the facts, specific details, and other pieces of information that a number of informants seemed to repeat helped to augment our understanding of the evolution of the digital infrastructure at RE/MAX (van Maanen, 1983), as did ideas generated by the three co-authors during periodic debriefing sessions.

Second, we followed a narrative strategy in which we constructed a detailed story from raw data (Langley, 1999, p. 695). We used background documents, publicly available information, and transcripts of interviews and meetings to create a detailed narrative history of the evolution of MainStreet. Though this strategy is descriptive in nature, it provides a mechanism for condensing the large volume of data and moving toward a more in-depth case study analysis (Eisenhardt, 1989). The narrative created a chain of evidence that allows others to "follow the derivation of any evidence from initial research questions to ultimate case study conclusions" (Yin, 1994, p. 84), thus increasing the reliability of the study. The resulting rich process description of our case formed an important basis for addressing our first research question—namely, how contradictory tensions were experienced and resolved at RE/MAX throughout the digital infrastructure evolution. More importantly, this also prepared us to address our second research question, namely, how to recognize the higher-order capabilities that drive strategic actions in resolving contradictory tensions, as articulated in the theoretical model.

Third, we employed a theoretical template strategy (Langely, 1999) by drawing on existing literature on digital infrastructure evolution, contradictory tensions, and ambidexterity. This step in the analysis involved a variation on qualitative pattern-matching between theory and data (see Campbell, 1975, and Yin, 1994), and allowed us to focus on contextual and process-oriented elements, as well as on the activities of key players associated with the evolution of MainStreet. We followed *open coding* and *axial coding* techniques as proposed by Strauss and Corbin (1990). During open coding, we categorized the data into concepts that were derived from individual and collective activities and from the interaction between business actors and technology that appeared to have influenced the digital infrastructure evolution. For example, informants often referred to "identifying members with complementary knowledge", "identifying relevant knowledge related to the infrastructure", and "absorbing new knowledge as a group" when they described how exploration-oriented activities were managed in the initiating phase of MainStreet's evolution. These first-order codes were grounded in the case context.

Subsequently, we compared and contrasted these codes with the array of concepts discussed in the literature on digital infrastructures and ambidexterity to include second-order concepts (e.g., "structures" and "capabilities") that comprise multiple first-order concepts (Strauss & Corbin, 1998), as shown in Tables 3-8. Our interview transcripts were cross-checked to verify that concepts were supported by at least two sources of evidence. A key element in this analytical step was the creation of an event listing, a technique that can provide insight into "what led to what, and when" (Miles & Huberman, 1994, p. 110). The concepts derived from individual and collective activities and from the interaction between business actors and the digital infrastructure represent our interpretation, based on evidence gathered from interviewees. By comparing incidents across the categories that emerged during axial coding, we organized, clustered, and mapped the theoretical components into metaconcepts, as shown in Table 2. As these concepts became integrated and further data collection did not cause modifications but rather reinforced the properties already identified, the concepts were deemed theoretically saturated.

Fourth, several contacts at the research site reviewed the narrative, incident charts, and theoretical map, which allowed detailed discussion of the findings. In these discussions, different interpretations were provided by our contacts, which resulted in an increased understanding and a richer analysis. The entire analysis was iterative and involved moving back and forth among the data, the existing literature, and the concepts that emerged as salient at the research site. In the next section, we present the evolution of the digital infrastructure that took place at RE/MAX.

Table 2. Concept Code List and Sources

Concept code	Code definition	Source
Contradictory tensions	Contradictory yet interrelated tensions that exist simultaneously and persist over time; such tensions seem logical when considered in isolation, but irrational, inconsistent, and absurd when juxtaposed	Smith & Lewis, 2011; Putman, Fairhurst, & Banhart 2016
Supporting leadership	Management distinctive role of articulating goals, developing skills, and setting routines to sense new opportunities, and then seize them and reconfigure the organization accordingly	Augier & Teece, 2009; Jansen et al., 2009; Xue et al., 2012
Supporting structure	Firm mechanisms to recombine and reconfigure assets and allocate, coordinate, and supervise tasks to support the digital infrastructure	Teece, Pisano, & Shuen, 1997; Teece, 2007
Supporting differentiated structure	Using a separate unit to manage all exploration and exploitation activities	Benner & Tushman, 2003; Duncan, 1976
Supporting independent structure	Using specialized units to manage either exploration or exploitation activities	Bower & Christensen, 1995; Jansen et al., 2009
Supporting Integrated Structure	A structure using a set of formal and informal mechanisms and involving various levels of the firm in managing exploration and exploitation activities	Gibson & Birkinshaw, 2004; Westerman et al., 2006
Ambidexterity	Ability to balance exploration and exploitation activities	March, 1991; O'Reilly & Tushman, 2008, 2013; Zimmermann et al., 2015
Exploration activity	Activities that increase variation by creating new opportunities to focus more on the future, such as innovation and discovering new possibilities	Baum et al., 2000; March, 1991; Smith & Tushman, 2005
Exploitation activity	Activities that help a firm to learn from its local search, and to select and reuse its existing knowledge and routines so that it can make improvements in efficiency and implementation	Baum et al., 2000; March, 1991; Smith & Tushman, 2005
Identifying capability	*Ability to recognize, establish, and determine the value of the digital infrastructure to the firm as well as the potential drawbacks*	*In vivo*
Germinating capability	*Ability to give embryonic protection by addressing needs with resources and providing support*	*In vivo*
Expanding capability	*Ability to increase in functionality and innovation, develop further, and increase or extend the use of the digital infrastructure*	*In vivo*
Legitimizing capability	*Ability to affirm and give a functional space to the digital infrastructure within the firm and in accordance with operational rules and standards*	*In vivo*
Augmenting capability	*Ability to make the digital infrastructure produce better results or value, and augment flexibility by increasing stakeholder involvement*	*In vivo*
Implanting capability	*Ability to embed the digital infrastructure firmly and deeply within the firm and make it an integral part of operations*	*In vivo*

Note: Grounded, in vivo codes are shown in italics. Several codes that were used to identify cases and interviewees have been omitted

4   Case Description

RE/MAX's business goal is to sell franchises and recruit and retain real estate agents. To accomplish this, the firm provides its network of franchisees with a strong brand name, proven business practices, and operational support (including training and education, IT support, and timely market knowledge). Its founder, Dave Liniger, understood that IT was the foundation of doing business in the digital economy, particularly in information-sensitive industries like real estate. Since the late 1980s, RE/MAX has invested and embarked on IT initiatives that often lead the industry. In particular, RE/MAX developed MainStreet, which started as a basic agent-centric intranet and evolved into a multifunction, multi-interface, and multi-stakeholder digital infrastructure. This study focuses on the evolution of MainStreet since its inception in 1998.

Although the evolution of a digital infrastructure can be perceived as a set of discrete events over time, our case shows the importance of distinguishing various temporal phases explicitly since the contradictory tensions are not homogenous across time. We therefore began by recognizing points of significant change— that is, dramatic changes in the challenges faced, as well as in the leadership and structures. We identified three distinct phases of a digital infrastructure evolution—initiating, cultivating, and growing. The emphasis in the initiating phase is on learning and identifying the digital infrastructure charter while understanding its strategic potential within the firm and avoiding letting it become a distraction that could drain resources. The first condition during the *initiating phase* is to have a general awareness of the new digital infrastructure and its perceived potential impact to solve a business need or opportunity of sufficient proportion to capture the attention of a sponsor group. In the *cultivating phase,* the focus is on nurturing the digital infrastructure, typically a prototype or a limited solution, to evaluate its impact on a reduced domain. If the infrastructure begins to yield benefits, potentially valuable innovations are added while its existing functionality is preserved, and leaders are encouraged to expand their efforts, as suggested by McGrath et al. (1996). By the *growing phase*, there is a high degree of consensus about the benefits of the digital infrastructure and a shared understanding of what it can offer is well disseminated across the organization. Some understanding is embedded in the digital infrastructure itself, and some is embedded in the structures, routines, and prescribed practices.

Each of the phases provides a way of structuring our findings around a certain continuity in the activities relating to the evolution of the digital infrastructure that took place at RE/MAX. As recommended by Langley (1999), this temporal structuring allows establishing comparative units of analysis that we use in the analysis and discussion sections. In the following subsections, we detail each phase of the evolution of MainStreet at RE/MAX.

4.1   The Initiating Phase (1998-2001)

In early 1998 the Internet was already widely used across several industries and companies, but it had not yet been adopted within the real estate industry. Several brokers and agents at RE/MAX raised the idea of using the Internet internally. Although they perceived its potential benefits, RE/MAX lacked the expertise and technical infrastructure to support it. Liniger worried that an investment in the Internet would be a cash drain for the company and an attention diversion for associates, but agreed to look into it.

Liniger followed through by asking his director of IT, Bruce Benham, and the manager of the IT User Support group, Kristi Graning, to examine the possibilities. A RE/MAX officer recalled how "Liniger chose his early explorations and members of the team carefully, knowing how critical it was to get accurate scouting reports of the terrain ahead". Liniger's knowledge of RE/MAX and his passion for training and education was complemented by Benham's formal IT training and Granings' operational experience in managing the IT User Support group. Rather than just jumping onto the Internet bandwagon, this corporate team began investigating the competitive situation and assessing the technology's business value for the firm. They flew around the country over the next few months, attended meetings as a team, shared ideas, assessed challenges, and set adoption objectives.

Given RE/MAX management's emerging technology expertise and the firm's nascent infrastructure, Liniger and his team engaged the services of Online System Services, Inc., to build, host, and manage this initiative. In July 1998 RE/MAX MainStreet was launched as a password-protected extranet connecting the firm's associates and staff. The investment in the new digital infrastructure was based on the perceived operational improvements and cost reductions. As Benham explained at the time of the launch, "RE/MAX MainStreet will greatly enhance the communication process—and save everyone time and money— by moving away from phone calls, faxes and express mail" (Harkins & Hollihan, 2005).

The team enacted a shared view of the future by pulling together collective wisdom from across the company. As the team grasped the Internet's potential, they realized that the company's new initiative was not solely about IT. Instead, they formulated a strategy aimed at using the capability of this technology as a crucial vehicle for bringing together different elements of the RE/MAX brand and providing information, training, and resources to the company's associates. At the same time, aware that the company had limited

skills and expertise and lacked an appropriate technical infrastructure, the team turned to outsourcing to overcome these deficiencies and avoid draining the company's scarce resources.

4.2 The Cultivating Phase (2001-2007)

By mid-2001, managing the expansion of MainStreet was becoming a challenge for the corporate team as it became clear that in-depth knowledge of this digital infrastructure was kept within the team and that only limited knowledge had been diffused to the rest of the firm. In addition, the increasing need for resources to keep innovating and expanding the functionality of this infrastructure was difficult to justify, as only a small proportion of agents were using it. Furthermore, although the corporate team was working hard in communicating the benefits of MainStreet and coordinating day-to-day operational activities relating to the use of MainStreet, as mentioned by a RE/MAX agent, "they lacked the capability to stay tuned to the field and listen to successes and failures to further improve it".

Liniger made the decision to promote the members of the corporate team. Benham became chief operations officer (COO) and Graning became the head of corporate IT. Two separate units were created, each reporting to corporate IT: the IT department and eBusiness. The IT department, which was engaged in exploitative activities, was responsible for overseeing application development, systems administration, business analytics, quality assurance, network operations, infrastructure, data center operations, network security, and desktop support. eBusiness initially focused on technological exploration activities to better support agents and brokers. External IT consultant John Daniels explained: "The IT department is more in the execution of the technology. The other one [eBusiness] is looking for the next functionality".

The IT department made MainStreet the hub of RE/MAX's existing IT applications aimed at supporting the productivity of its agents. In December 2006, the company integrated RE/MAX Design Center into MainStreet, legitimizing an IT application that was originally developed at three of its affiliates (RE/MAX of New Jersey, California, and Hawaii). This service offered a full suite of online marketing tools available exclusively through RE/MAX MainStreet, including brochures, flyers, presentation cards, printing and mailing services, ad campaigns, electronic greeting cards, virtual tours, slideshows, and multimedia presentations—complete with web traffic reporting tools to identify the performance of online marketing campaigns.

The eBusiness department, on the other hand, actively sought providers of complementary resources and services to enhance MainStreet. During this phase,

MainStreet was redesigned several times in order to provide innovative services to RE/MAX associates and staff members. MainStreet added services such as breaking news, company information, online discussion threads, chat areas for real-time exchanges and conferences, and a library for documents, forms, and other resource materials. In addition, RE/MAX established agreements with different providers who offered their services to its franchise members through MainStreet. In 2006 RE/MAX partnered with eNeighborhoods, one of the largest MLS data providers in the United States, to launch RE/MAX LeadStreet: a proprietary online sales lead-generator and lead management tool. In September 2007, RE/MAX unveiled RE/MAX University, a comprehensive training service that expanded its earliest satellite training services to provide broadcast, online, and classroom educational services all under one umbrella and offered through RE/MAX MainStreet.

The product management, training, and support units within the IT department and eBusiness were involved in both exploitative and exploratory activities. Exploitative activities included communicating and coordinating existing and new IT applications across the RE/MAX network and managing relationships with franchisees. Executive Director of Membership Jamie Geer explained that employees in those units are

> *those middlemen and that voice between the contract that they [franchisees] have signed and their five-year term and that voice who continues to say, "this is the value, this is why you are part of RE/MAX, this is what we have continued to create that you can offer your agents".*

Furthermore, a RE/MAX product manager reflected that:

> *Agents want to make money. So, we are there to help them by showing how to utilize these tools to make more money…. Technology trainers are traveling two to three weeks a month, and are responsible for delivering the message, delivering the communication about our existing technologies.*

At the same time, given that these technology trainers were the interface between the RE/MAX offices and headquarters, they were also in a position to discover new needs as well as to suggest improvements to MainStreet. For example, Geer commented:

> *Technology initiatives such as LeadStreet and Design Center came from our affiliates. I can tell you that Northern Illinois and New Jersey had a LeadStreet initiative setup well before us. They were aggregating listing services and getting all listings on a website*

for a consumer base to view. We have always said the best ideas come from the field. The best ideas start small because the regions have the flexibility. They have fewer people to explain how they spend money. We just took the idea and made it work for the whole franchise.… So, our job is to decide what we roll out and when to say, "handle it at your office level".

4.3   The Growing Phase (2008-2012)

Early in 2008 MainStreet's capacity to grow and to leverage, adapt, and access a range of real estate services began to be constrained by design and investment decisions made during the cultivating phase. MainStreet underwent many iterations and modifications to meet the evolving needs of the business and the associates, making it difficult for RE/MAX to keep the digital infrastructure fresh and grow its functionality.

The third phase began early in 2008 when the company's senior management began to realize how strategically important the digital infrastructure was becoming for RE/MAX and its associates. The infrastructure's lack of flexibility was also becoming apparent, and there were difficulties coordinating with the outsource provider over the changes needed. Marie Blanco, the VP of eBusiness, explained:

[MainStreet] had been pieced together over the years.… We limped along with it, but we didn't do a lot of integration. We did the minimal support so that people could at least sign into MainStreet, click LeadStreet, and get into the LeadStreet system, so we just did a single sign-on pass-through at that time.... We applied bandages to it beyond belief. It wasn't flexible, it couldn't scale, and the technology badly needed to be updated.

Graning added:

We didn't have any flexibility with [the outsourcing provider]. We didn't have the control and the resources to make MainStreet do what the business needed it to do. Simple changes could take anywhere from two to eight weeks, and they would charge us several hundred dollars.

Furthermore, during the first two phases of MainStreet's evolution, RE/MAX headquarters covered all the expenses of building and maintaining the platform. As it became more complex, however, top management made the decision that MainStreet was to be financed by the franchisees as part of the RE/MAX's national advertising fund. This created an economic incentive for the IT-focused staff at

RE/MAX. They understood, as Geer explained, that "the more agents I can get, the more money I can spend in the national ad fund that would sponsor new technologies". This approach was also helpful in securing financial support even during the downturn in the real estate industry. On the other hand, this decision also implied a need to accommodate competing goals from multiple stakeholders. Blanco explained,

Back then, when we came up with an idea, we would spend several hours putting a business plan together.… OK, let's get [it] approved and then we started pulling all the people and the pieces together. Today that is not how it works at all. It is not right or wrong. It is just different. It is a very committee-based type of decision making. Today franchisees want to have involvement, provide input, and have a say in how things get implemented. Very rightfully so, as technology impacts their agents and brokers and they want to be a part of that.

Liniger again played an important role in overseeing the digital infrastructure evolution in this phase. He respected the autonomy of the structural unit in charge of managing the infrastructure, but also created a sense of accountability and tracking progress. Blanco summarized this approach in explaining that "the management vision of how this all works follows an eagle-eyed approach overseeing the changes in the technology". Liniger, however, became concerned that the exploration activities realized by eBusiness were mainly focused on the short term. He therefore decided to change the organizational structure once more in late 2009 in order to better identify and explore new long-term IT trends. Blanco reflected that:

Our executive management team made the decision that our Senior VP of eBusiness needed to focus more on emerging technologies.… So, now she is looking at what the next big thing is for RE/MAX… The IT department was moved to report directly to the RE/MAX COO.

Graning, explained "I have to keep an eye on the ball on what is happening. I am online all the time, I am following people on Twitter, I am listening to technologists, and I am listening to companies".

Early in this phase, RE/MAX recognized that to grow MainStreet further, integrate it with other company operations, make its business operations more efficient, and enable it to maintain a strong connection with its associates, MainStreet needed to be hosted and managed in-house. RE/MAX contracted external consultants to help insource the development, operation, and maintenance of MainStreet. It also selected and acquired a specialized technology and

business model in order to provide MainStreet services in-house. It engaged the help of Analysis International Corporation, a company specializing in collaboration, infrastructure, and project and application solutions, and proceeded to redesign MainStreet.

At the same time, MainStreet kept innovating and growing in functionality. Graning commented:

> *MainStreet is the funnel for doing business with RE/MAX. It's the one place all of our associates go to get the information they need. This is a huge organization and, as such, it is essential to a franchisee's business that the associates have central access to information.*

Furthermore, the decision that MainStreet was to be financed as part of the RE/MAX's national advertising fund also implied that a committee made up of representatives from different parts of the RE/MAX network would have to agree on how the national advertising fund was used. So, in addition to the formal management structure of MainStreet, RE/MAX also introduced ad hoc mechanisms to engage and provide closer communication and coordination with individuals who had various stakes in the technology's continued success, and this, in turn, balanced exploration and exploitation activities. Graning explained, for example, that:

> *Twice a year there is a formal process in which ideas are solicited from both within and outside the company. These suggestions help identify disruptive technologies, new business models, and attractive new markets. This effort typically results in several hundreds of ideas… These are scrutinized and reduced and small teams are formed to do a more detailed strategic analysis. Based on these findings, I will then begin to socialize promising ideas among senior executives and broker owners, to determine acceptance. Once ideas have passed this test, we will do a dive to properly understand the market opportunity.*

Blanco added:

> *We have formal and informal meetings to assess how any change would impact our membership and, then, how it would impact our recruiting and retention. Our bottom line is: How do we sell franchises recruit and retain agents? So, everything is driving towards those goals and saying, OK, how is this change that we are making way back here going to eventually impact that corporate goal?*

5 Analysis and Theoretical Integration

From our analyses, four main dimensions emerged, together with their second-order themes and the first-order concepts that led to the formation of those themes. The overarching emergent dimensions include the salient *contradictory tension*, *supporting leadership, supporting structure*, and *exploration-oriented* and *exploitation-oriented* activities that help to balance exploration and exploitation (i.e., achieve ambidexterity) in order to resolve the contradictory tension at each phase of the digital infrastructure evolution. Eisenhardt (1989) advocates the approach of moving back and forth between theoretical conceptualization and case findings, noting that "overall, tying the emergent theory to existing literature enhances the internal validity, generality, generalizability, and theoretical level of theory building from case study research" (p. 545). Furthermore, we distinguish carefully between the insights we gained from observing of the path that unfolded within our case study's specific digital infrastructure setting and possible generalizations to other settings, which is what Lee and Baskerville (2003) refer to as "generalizing from case study findings to theory" (p. 236).

5.1 Balancing Exploration and Exploitation in the Initiating Phase

During this phase, a decision maker in a position of responsibility and authority becomes aware of the particular technology and decides to evaluate it further. The primary role of a decision maker during this phase is to foster conditions that will let management capture and exploit the knowledge that already exists inside and outside the firm. Table 3 shows the data structure of our findings during this phase of the digital infrastructure evolution, and Table 4 provides representative supporting data from RE/MAX for each second-order theme.

Table 3. Salient Contradictory Tensions, Supporting Leadership and Structure, and Tension Resolution in the Initiating Phase

Salient contradictory tension	• Introducing a digital infrastructure is perceived potentially as a means to save resources, but also as a distraction that could drain resources	
Supporting leadership	1st-order theme • Top management actively involved in choosing/formalizing the leading team • Top management actively involved in providing resources	2nd-order theme *Supporting top mgmt.*
	• Middle and operational management not involved	*Supporting middle & operational mgmt.*
Supporting structure	1st-order theme • Enabling a group of individuals to focus on the adoption • Balancing exploration and exploitation activities	2nd-order theme *Supporting differentiated structure*
Tension resolution (ambidexterity) exploration activities	1st-order theme • Identifying members with complementary knowledge • Identifying relevant knowledge about the infrastructure • Absorbing new knowledge as a group	2nd-order theme *Identifying capability*
Exploitation activities	1st-order theme • Crystallizing the objective of the digital infrastructure • Assessing the required technology competence • Establishing early funding to support the infrastructure	2nd-order theme *Germinating capability*

5.1.1 Contradictory Tension

During this phase, the salient contradictory tension is derived from the general awareness that the digital infrastructure could potentially save resources, but that it might also become a distraction that could drain resources. Prior research has identified this contradictory tension associated with digital infrastructures in general (Brynjolfsson & Saunders, 2009; Hanseth 2000), but not specifically in this phase of their evolution. Given that the firm's experience and technical infrastructure are limited, participants are unable to perceive the long-term implications, but there is a broad awareness that the digital infrastructure

could be an important determinant of the firm's ability to garner rents.

At RE/MAX, Liniger was aware of the need to invest in supporting the technology but was concerned that it would be a cash drain and an attention diversion. Furthermore, he was conscious that the Internet was being used extensively across various industries and companies and he realized its potential benefits for businesses. At the same time, he was sensitive to the fact that the real estate industry had not commonly adopted the Internet and that his company had limited expertise and skills and also lacked the technical infrastructure to support its use.

Table 4: Representative Supporting Data for Each First- and Second-Order Theme in the Initiating Phase

Second-order themes	First-order themes	Representative data and quotes from RE/MAX
Supporting top management	Top management actively involved in choosing/formalizing the leading team	"Liniger chose his early explorations and members of the team carefully, knowing how critical it was to get accurate scouting reports of the terrain ahead".
	Top management actively involved in providing the resources needed	"At that time, Liniger had to invest money into this project [MainStreet], so it could become a reality".
Supporting differentiated structure	Enabling a group of individuals to focus on the adoption	A corporate team was created separately from daily operations.
	Balancing exploration and exploitation activities	The team became a forum that examined the characteristics of the Internet solution, reflected on the needs of RE/MAX's associates, assessed existing practices and cross-functional processes and systems, and planned for the new strategic initiatives.
Identifying capability	Identifying members with complementary knowledge	Liniger's knowledge of the industry was complemented by Benham's formal IT training and Graning's operational experience in managing the IT Users group.
	Identifying relevant knowledge about the infrastructure	The corporate team attended meetings, shared ideas with other firms, and negotiated with potential technology providers as well as providers of complementary services.
	Absorbing new knowledge as a group	The corporate team enacted a shared view by pulling together collective wisdom from across the firm.
Germinating capability	Crystallizing the objective of the digital infrastructure	As corporate team members grasped the potential of the Internet, they established a strategic aim to adopt it as a vehicle for bringing together different elements of the RE/MAX brand and providing information, training, and resources to the company's associates.
	Assessing the required technology competence	Given the lack of technological expertise and infrastructure, RE/MAX partners with OSS, Inc., to develop, host, and manage MainStreet.
	Establishing early funding to support the infrastructure	Given that the technology was to "enhance the communication process—and save everyone time and money—by moving away from phone calls, faxes, and express mail", every agent had to pay a fee to use it.

5.1.2 Supporting Leadership

During the initiating phase, top management is the driving force behind the technological initiative and is actively involved in identifying and nurturing it while also assessing its drawbacks. This involves seeking out people both inside and outside the organization who already have experience with the new technology and helping to articulate the vision. At the same time, top management also needs to build a team with the required competencies, set goals, offer support, nurture resources, and provide motivation through a stretching intent and by pushing people to achieve goals and

having trust in them. As our study demonstrates, each of these strategies enhances learning by top managers who play a pivotal role in driving ambidexterity (Lubatkin et al., 2006; Probst, Raisch, & Tushman, 2011).

5.1.3 Supporting Structure: Differentiated

Our analysis suggests that during the initiating phase, having a dedicated corporate team is useful because it enables knowledge to be absorbed at the top of the organization in a unified way, allows the team to manage the nurturing resources close to the locus of change, and shields the team from the rest of the organization. It enables the team to pursue exploration

and exploitation simultaneously, through activities that involve understanding the characteristics of the new technology, assessing potential drawbacks, and reflecting on the needs of the various stakeholders. At the same time, the team will also be evaluating existing providers of core and complementary technologies and services as well as planning and steering the charter definition of the new digital infrastructure. This concurs with prior ambidexterity research suggesting that the necessary balance can be maintained by developing a supportive organizational structure within a particular organizational unit (Benner & Tushman, 2003; Duncan, 1976).

5.1.4 Ambidexterity (Tension Resolution)

We find two capabilities, *identifying* and *germinating*, that are critical in balancing exploration and exploitation during this phase to resolve the contradictory tension mentioned above. These capabilities create a virtuous cycle as the search for a new digital infrastructure and for business opportunities is fostered and new knowledge is shared internally as well as externally to the firm; at the same time, the new digital infrastructure is nurtured and protected during this embryonic phase.

Identifying is the ability to recognize, establish, and determine the value of the digital infrastructure to the firm as well as the potential drawbacks. The case show that critical exploration-oriented activities in solving contradictory tensions during this phase include identifying members with complementary knowledge, identifying relevant knowledge about the infrastructure, and absorbing new knowledge as a group. At RE/MAX, the corporate team met every day for several months to work specifically on this initiative—it became a large part of a few people's jobs, instead of a small part of many people's jobs. The team became a forum that examined the digital infrastructure characteristics, reflected on the needs of associates, assessed existing practices and cross-functional processes and systems, and planned for the new initiative. Top management did not begin with a grand plan of where RE/MAX was heading when the decision was made to investigate the potential of using the Internet within the firm. The corporate team articulated and described the immediate steps that were manageable, and it was this articulation that set a force into action (Oliver, 1997).

Germinating is the ability to give the embryonic digital infrastructure protection by providing the resources and support required. After identifying a potential digital infrastructure, it is important to seize and nurture its potential to meet a particular business need while avoiding draining resources in supporting it. In the initiating phase, critical exploitation-oriented activities include crystallizing the objective of the digital infrastructure, assessing the required

technological competence, and establishing the initial funding to support the infrastructure. At RE/MAX, as understanding of the technology increased and the existing resource constraints became clearer, the corporate team realized that it would require far more resources than could be provided by the firm. The stretch—the mismatch between resources, expertise, and aspirations—was an important problem faced by this team in protecting the embryonic digital infrastructure. Given that the firm did not have all the skills and expertise required to set up the digital infrastructure, acquiring them through outsourcing was important in enabling the team to seize the opportunities offered by this new technology.

5.2 Balancing Exploration and Exploitation in the Cultivating Phase

Our study suggests that during this phase integrating resources into the core activities of the technical solution is crucial in expanding the scope of the digital infrastructure while legitimizing its use within the firm, as presented in Table 5. Table 6 provides representative supporting data from RE/MAX for each of these concepts.

5.2.1 Contradictory Tension

During this phase, the salient contradictory tension derives from the fact that the expanding digital infrastructure requires resources to support and coordinate its day-to-day operations but also needs them to innovate and increase its functionality. Gal, Lyytinen, and Yuoungjin (2008), Monteiro et al., (2013), and Rodon and Silva (2015) have explained this contradictory tension in digital infrastructures but not specifically within their evolution. At RE/MAX, the corporate team worked hard at communicating and coordinating day-to-day operational activities relating to MainStreet. However, changes were still needed so that the team could understand why some attempts to improve the system had worked, while others had not. Furthermore, given that during the previous phase the responsibility for the digital infrastructure had resided exclusively within the corporate team, this structural arrangement led to tensions that created a sense of isolation, delayed wider awareness-raising of the technology and the problems that it could solve, and hindered communication and coordination of day-to-day operational activities relating to the digital infrastructure.

5.2.2 Supporting Leadership

During this phase, top management plays an important role in managing the transition from a differentiated corporate team into two separate operational units. It is actively involved not only in carefully selecting and assigning the operational leaders for both operational

units, but also in positioning the digital infrastructure within the firm, facilitating the knowledge and resource flow, and granting subordinates sufficient autonomy to keep the infrastructure evolving. At RE/MAX, Liniger's leadership was crucial in assigning members of the corporate team to lead and guide the two separate organizational units and ensure cooperation and support not only between the two units but also from partner firms. On the other hand, the role of middle managers in this phase is to expand the digital infrastructure while legitimizing its use in the firm. It requires a group of middle managers to craft an engaging vision to increase the use of the digital infrastructure, monitor new opportunities, and generate innovative ideas to improve the infrastructure. At the same time, a different group of middle managers is needed in overseeing day-to-day tasks, establishing processes, providing clear targets, addressing problems when they occur, and handling external partners.

Table 5: Salient Contradictory Tension, Supporting Leadership and Structure, and Tension Resolution in the Cultivating Phase

Salient contradictory tension	• When expanding a digital infrastructure, resources are required to coordinate day-to-day operations, but also to innovate and increase the functionality of the infrastructure.
Supporting leadership	1st-order theme 2nd-order theme • Top management actively involved in positioning the digital infrastructure within the firm, assigning operational leaders and providing resources ⟩ *Supporting top mgmt.* - • Middle management involved in finding creative ways to roll out the digital infrastructure • Operational management involved in embracing the digital infrastructure ⟩ *Supporting middle & operational mgmt.*
Supporting structure	1st-order theme 2nd-order theme • Formalizing the initial working group as an operational unit • Separating the management of exploration and exploitation ⟩ *Supporting independent structure*
Tension resolution (ambidexterity) exploration activities	1st-order theme 2nd-order theme • Expanding through complementary technologies and services found outside the firm • Expanding through complementary technologies and services found inside the firm ⟩ *Expanding capability*
Exploitation activities	1st-order theme 2nd-order theme • Technology becomes part of day-to-day operations • Leveraging and co-opting technology and services from outside the firm to expand the digital infrastructure • Legitimizing initiatives taken by individual offices/affiliates • Establishing corporate funding to support adoption ⟩ *Legitimizing capability*

Table 6: Representative Supporting Data for Each First- and Second-Order Theme in the Cultivating Phase

First-order themes	First-order themes	Representative data and quotes from RE/MAX
Supporting top management	Top management actively involved in positioning the digital infrastructure within the firm, assigning operational leaders and providing resources	Liniger formalized the functional structure to house the initiative and provided the funding needed.
Supporting Middle and Operational Management	Middle management involved in finding creative ways to roll out the digital infrastructure	"My job was to do marketing communications to our members and run contests to get people to use MainStreet…. For example, MainStreet Madness was wrapped around a basketball theme in March. We did an entire campaign to get our members to use it". "We identified opportunities…. Technology initiatives like Design Center and LeadStreet came from affiliates. We took the idea and made it work for the whole franchise".
	Operational management involved in embracing the digital infrastructure	"Brokers can recruit and retain agents more easily by making available to them technological tools that generate leads and referrals, facilitate network communication, and track listing and sales activities". "We have always said the best ideas come from the field. The ideas start small because the regions have the flexibility. They have fewer people to explain how money is spent".
Supporting independent structure	Formalizing the initial working group as an operational unit	A member of the corporate team, Kristi Graning, was promoted to head of Corporate IT to manage MainStreet.
	Separating the management of exploration and exploitation	Two separate units were created, reporting to Corporate IT: "The IT department is more in the execution of the technology. The other one [eBusiness] is looking for the next functionality".
Expanding capability	Expanding through complementary technologies and services found outside the firm	"To understand further the opportunities that MainStreet could bring to the company, the eBusiness department actively sought providers of complementary resources and services that could be integrated".
	Expanding through complementary technologies and services found inside the firm	"In eBusiness, we devoted part of our planning to evaluating initiatives developed at different RE/MAX affiliates".
Legitimizing capability	Crystallizing the objective of the digital infrastructure	MainStreet was redesigned several times to provide most of the resources needed by RE/MAX associates and staff members. MainStreet added services such as breaking news, company information, online discussion threads, chat areas, and a library for documents, forms, and training materials.
	Leveraging and co-opting technology and services outside the firm to expand the digital infrastructure	RE/MAX established agreements with different providers who offered their services to all its franchise members.
	Legitimizing initiatives taken by individual offices/affiliates	"We [at eBusiness] just took the idea and made it work for the whole franchise… So, our job is to decide what we roll out and when to say, 'handle it at your office level'".
	Establishing corporate funding to support adoption	The fee charged to agents for using the technology was removed. Instead, headquarters provided the funding needed to expand the digital infrastructure.

5.2.3   Supporting Structure: Independent

In the cultivating phase, the structure supporting the digital infrastructure shifts from the differentiated corporate team into two independent operational units. One of these units is responsible for continuing learning and finding creative ways to expand the technology, drive change, and make improvements, and the other for designing effective processes, reacting to operational challenges, and managing the relationships with providers of the core and complementary technologies and services. Establishing independent units configured to pursue either exploration or exploitation according to the specific requirements of each unit's task environment can be beneficial (Tushman & O'Reilly, 1996). Such structural separation creates "pragmatic boundaries", which facilitate units to focus on exploration or exploitation while protecting them from being affected by the rest of the organization (Carlile, 2004). At RE/MAX, the cultivating phase began with the creation of two independent units: eBusiness and the IT department. eBusiness was the smaller and more flexible of the two units and specialized in pursuing exploration and learning from a broad spectrum of actual and potential MainStreet users and partners. The IT department, on the other hand, shouldered the burden of integrating MainStreet with the rest of the organizational processes and the existing technological infrastructure. Given that both units reported to Corporate IT, the distance between them allowed them to leverage each other's competencies, spreading the required knowledge quickly and efficiently and reducing the level of support required and friction involved in expanding the use of MainStreet.

5.2.4   Ambidexterity (Tension Resolution)

We find two capabilities, *expanding* and *legitimizing*, that are critical during the cultivating phase in resolving the tension discussed above and creating a virtuous cycle as the digital infrastructure develops further and its scope enlarges, while at the same time it receives a functional space within the firm's operational rules and standards.

Expanding is the ability to increase the functionality and innovation, develop further, and increase or extend the use of the digital infrastructure. In the cultivating phase, critical exploration-oriented activities that help to resolve contradictory tensions include those that relate to gaining new insights and recognizing complementary technologies and services from inside and outside the firm that could be incorporated. At RE/MAX, during this phase, the infusion of innovations from outside partners and service providers was an important enabler in expanding MainStreet. In addition, eBusiness devoted an important part of its planning to evaluating initiatives developed at different affiliates so that the unit had a better understanding of opportunities to improve MainStreet.

Legitimizing is the ability to affirm and give a functional space to the digital infrastructure within the firm and in accordance with operational rules and standards. During the cultivating phase, it is important to ensure the digital infrastructure becomes a formal part of the firm's day-to-day work and its operational rules and standards. Critical activities include communicating to the rest of the organization that the digital infrastructure is part of day-to-day operations, leveraging and co-opting technology from outside the firm to expand the digital infrastructure, legitimizing initiatives made by some offices and affiliates to be used by the whole firm, and establishing corporate funding to support adoption of the infrastructure. This is in accordance with prior findings that competency building is affected by the firm's ability to legitimize its strategic initiatives (Dosi & Marengo, 1992).

5.3   Balancing Exploration and Exploitation in the Growing Phase

Table 7 shows the data structure of our findings during the growing phase of the digital infrastructure evolution. Table 8 provides representative supporting data from RE/MAX for each second-order theme.

5.3.1   Contradictory Tension

During this phase, the salient contradictory tension derives from the fact that, as the digital infrastructure becomes embedded, there is the need for stable control over resources, but also for flexibility over how resources are controlled and the capacity to accommodate the competing goals of stakeholders. This tension arises from the continuous need to keep the digital infrastructure fresh and changing with the evolving business environment and as new expectations and requirements emerge. At the same time, pressures persist to embed the infrastructure even further in the firm, as identified by Scott and Wagner (2003) and Henningson and Henriksen (2011).

5.3.2   Supporting Leadership

During this phase, top management's role is to maintain oversight. Even though it is not as actively involved as in previous phases, top management relies on structural mechanisms to create a sense of accountability and track progress and, more importantly, to accommodate the needs of the multiple stakeholders now involved. Given the increased complexity arising from the growth of the digital infrastructure and the structural arrangements to support it, middle managers are involved in stabilizing the infrastructure operation and installing reliable processes, while simultaneously accommodating stakeholders' competing needs and goals. Furthermore, as the digital infrastructure becomes firmly established in the firm and the fear over whether it will be adopted has dissipated, middle management

engages in shared activities and builds teams of operational managers with different types of complementary capabilities—including task complementarities (for example, defining and assigning clear functional roles for subunits), expertise complementarities (for example, teams made up of members with differing levels of training and experience through their various positions and roles), and social complementarities (arising from the different skills and personalities of the team members). These complementarities help increase the variety of skills required to give the flexibility to explore different ways of delivering the digital infrastructure more efficiently and to search creatively for new ways of deriving value. At the same time, they also provide more stability for the operation of the infrastructure, facilitate cooperation, support efficient decision-making processes, and focus everyone on common objectives.

Table 7: Salient Contradictory Tension, Supporting Leadership and Structure, and Tension Resolution in the Growing Phase

Salient contradictory tension	• An embedded digital infrastructure requires stable control over resources and increased stakeholder involvement, but also flexibility in controlling those resources and in accommodating stakeholders' competing goals
Supporting leadership	1st-order theme 2nd-order theme • Top management involved in maintaining oversight while giving autonomy to operational units → *Supporting top mgmt.* - • Middle management involved in stabilizing the infrastructure operation and processes while seeking ideas for improvement • Operational management involved in further developing the digital infrastructure → *Supporting middle & operational mgmt.*
Supporting structure	1st-order theme 2nd-order theme • Creating structures to specialize further in exploration and exploitation • Formalizing structural mechanisms to involve key stakeholders → *Supporting integrated structure*
Tension resolution (ambidexterity) exploration activities	1st-order theme 2nd-order theme • Continuously identifying ways of integrating the digital infrastructure • Involving key stakeholders in further developing the digital infrastructure → *Augmenting capability*
Exploitation activities	1st-order theme Second-order theme • Investing in a stable digital infrastructure base • Establishing a stable funding model for the digital infrastructure → *Implanting capability*

Table 8: Representative Supporting Data for Each First- and Second-Order Theme in the Growing Phase

Second-order themes	First-order themes	Representative data and quotes from RE/MAX
Supporting top management	Top management involved in maintaining oversight while giving autonomy to operational units	"The management vision follows an eagle-eyed approach in overseeing the changes in the technology. We have meetings to assess how any change [in the technology] would impact our membership and, then, how it would impact our recruiting and retention, for example".
Supporting middle and operational management	Middle management involved in stabilizing the infrastructure operation and processes while seeking ideas for improvement	"Middle management at RE/MAX provided training, communication, and coordination with individuals who are involved with MainStreet".
	Operational management involved in further developing the digital infrastructure	"Back then [second phase], when we came up with an idea, we would spend several hours putting a business plan together.… Today franchisees want to have involvement, provide input, and have a say in how things get implemented. Very rightfully so, as technology impacts their agents and brokers and they want to be a part of that".
Supporting integrated structure	Creating structure to further specialize in exploration and exploitation	RE/MAX created a VP of Emerging Technologies position, responsible for identifying and exploring new long-term IT trends. On the other hand, the IT department, responsible for support of MainStreet, was moved to report directly to the RE/MAX COO.
	Formalizing structural mechanisms to involve key stakeholders	Several structural mechanisms were established to communication and coordination with the technology stakeholders, which in turn balanced exploration and exploitation activities.
Augmenting capability	Continuously identifying ways of integrating the digital infrastructure	Given the strategic importance of the Internet for RE/MAX and its associates, RE/MAX top management hired external consultants to help them identify ways to further integrate its digital infrastructure with the company's operations.
	Involving key stakeholders in further developing the digital infrastructure	"Twice a year ideas are solicited within and outside the company. These suggestions help identify disruptive technologies, new business models, and attractive new markets.… Based on these findings, I will then begin to socialize promising ideas among senior executives and broker owners, to determine acceptance".
Implanting capability	Investing in a stable digital infrastructure base	RE/MAX acquired a specialized technology infrastructure base to provide MainStreet services in-house.
	Establishing a stable funding model for the digital infrastructure	MainStreet became financed by the franchise itself (not by headquarters) as part of its national advertising fund.

5.3.3 Supporting Structure: Integrated

No business unit in an organization has all the internal capabilities necessary to manage a successful digital infrastructure, especially when it is making rapid technological advances (Powell, Koput, & Smith-Doerr, 1996). This creates a demand for specific knowledge and resources from other business units (Lavie & Rosenkopf, 2006). In the growing phase, the structural arrangement (two separate operational business units) that led the digital infrastructure in the cultivating phase naturally outgrows its ability to use only employees from those units to interpret, integrate, and engage in coherent exploration and exploitation activities. Cooperating in technology activities, transferring employees between departments, creating company-wide funding to support the digital infrastructure, and establishing cross-unit committees are examples of structural mechanisms that leverage the expertise of individuals, keep knowledge circulating continuously, and ensure cross-fertilization between business units (O'Reilly & Tushman, 2008; Taylor & Helfat, 2009). They also help keep the infrastructure from becoming inflexible and outdated and help managers consider how the future can or may be different from the past. Integrating formal and informal structural mechanisms in order to cope with the competing demands that arise from the simultaneous pursuit of exploitation and exploration in this phase of the digital infrastructure evolution is consistent with the concept of contextual ambidexterity (Gibson & Birkingshaw, 2004; Im & Rai, 2008). Contextual ambidexterity refers to a set of mechanisms within the organization that facilitate and encourage organizational units and employees to do contradictory tasks at the same time (Gibson & Birkinshaw, 2004).

5.3.4 Ambidexterity (Tension Resolution)

We find two capabilities, *augmenting* and *implanting*, to be critical during this phase in resolving the contradictory tension mentioned above and in creating a virtuous cycle to keep the digital infrastructure fresh and produce value. At the same time the help in embedding digital infrastructure even further within the firm, making it an integral part of the firm's operations.

Augmenting is the ability to make the digital infrastructure produce better results or value, and augment flexibility by increasing stakeholders' involvement. Since the digital infrastructure is embedded in the organization, exploration activities during this phase are driven mainly by continuously identifying ways of integrating the digital infrastructure as well as involving key individuals—especially those with various stakes in the infrastructure's continued success. This helps to facilitate the circulation of new knowledge, produce

better results, and extract further value from the infrastructure. By augmenting the sources of relevant knowledge and fostering collaboration and better understanding, organizations ultimately strengthen and fuel the growth of their digital infrastructure (Henfridsson and Bygstad 2013). This finding also concurs with past research that shows that intra-unit and inter-unit boundary spanning enables the exploration of knowledge (Miller, Fern, & Cardinal, 2007).

Implanting is the ability to fix the digital infrastructure firmly and deeply within the firm and make it an integral part of operations. In the growing phase, the focus of the exploitation activities is on investing in a stable digital infrastructure base and establishing a funding model to embed the technology firmly in the day-to-day routines, drive its ultimate impact on the business, and stimulate both the digital infrastructure supply and demand to accommodate the needs and goals of multiple stakeholders. The result is that the rate of assimilation increases further, a consequence of a positive feedback loop (Bikchandani, Hirshleifer, & Welch, 1992; Henfridsson & Bygstad, 2013). At RE/MAX, during this phase, the strategic importance attached to MainStreet and to meeting users' needs was well understood across the firm. Having assessed those needs, the firm acquired a specialized technological base. In addition, to further integrate the digital infrastructure and the business, it is critical during this phase to stabilize the business model (including the sources of funding to sustain and grow the digital infrastructure). This can help direct a firm's evolutionary path, as suggested by Teece, Pisano, and Shuen (1997).

6 Discussion: A Theoretical Model of Ambidexterity in the Digital Infrastructure Evolution

From our analysis and integration of the case study findings, we identified the static data structures for the key concepts that emerged, as displayed in Tables 3-8. In this section, we discuss the dynamic relationships among them that are the basis for our theoretical model of digital infrastructure ambidexterity, as shown in Figure 1. The model identifies three pairs of capabilities (identifying-germinating, expanding-legitimizing, and augmenting-implanting), three levels of supporting leadership (at the top, middle, and operational), and three types of supporting structure (differentiated, independent, and integrated) that help in resolving salient contradictory tensions (ambidexterity) in each phase. Further, while some of the management strategies that contributed to ambidexterity at RE/MAX were deliberate and intended, others evolved as learning and capability accumulation took place. Thus, the study shows that digital infrastructure ambidexterity involves deliberate

investment in processes that have been characterized in prior literature as the firm's ability "to learn how to learn" (Danneels, 2002). This model should be seen as a theory-building exercise that may then be subjected to empirical scrutiny in future research. Accordingly, we put forward a set of observations with regard to managing contradictory tensions in the evolution of digital infrastructure.

In relation to leadership, the model identifies the role that top, middle, and operational management play in supporting digital infrastructure ambidexterity. It thereby answers the call from Andriopoulos and Lewis (2009) for more research that addresses the tensions between exploitation and exploration at multiple levels

of management. Prior research has found that top management plays a crucial role in facilitating a firm's ability to perform better (Smith &Tushman, 2005), shaping individual behavior (He & Wong, 2004), and resolving tensions by creating integrative and synergetic value between exploration and exploitative activities that support organizational ambidexterity (Jansen et al., 2009; Xue, Ray, & Sambamurthy, 2012). However, the role of middle and operational management in organizational ambidexterity has received less attention (Zimmermann, Raisch, & Birkinshaw, 2015). Our study shows that these three management levels have important yet distinct roles at each phase of digital infrastructure evolution.
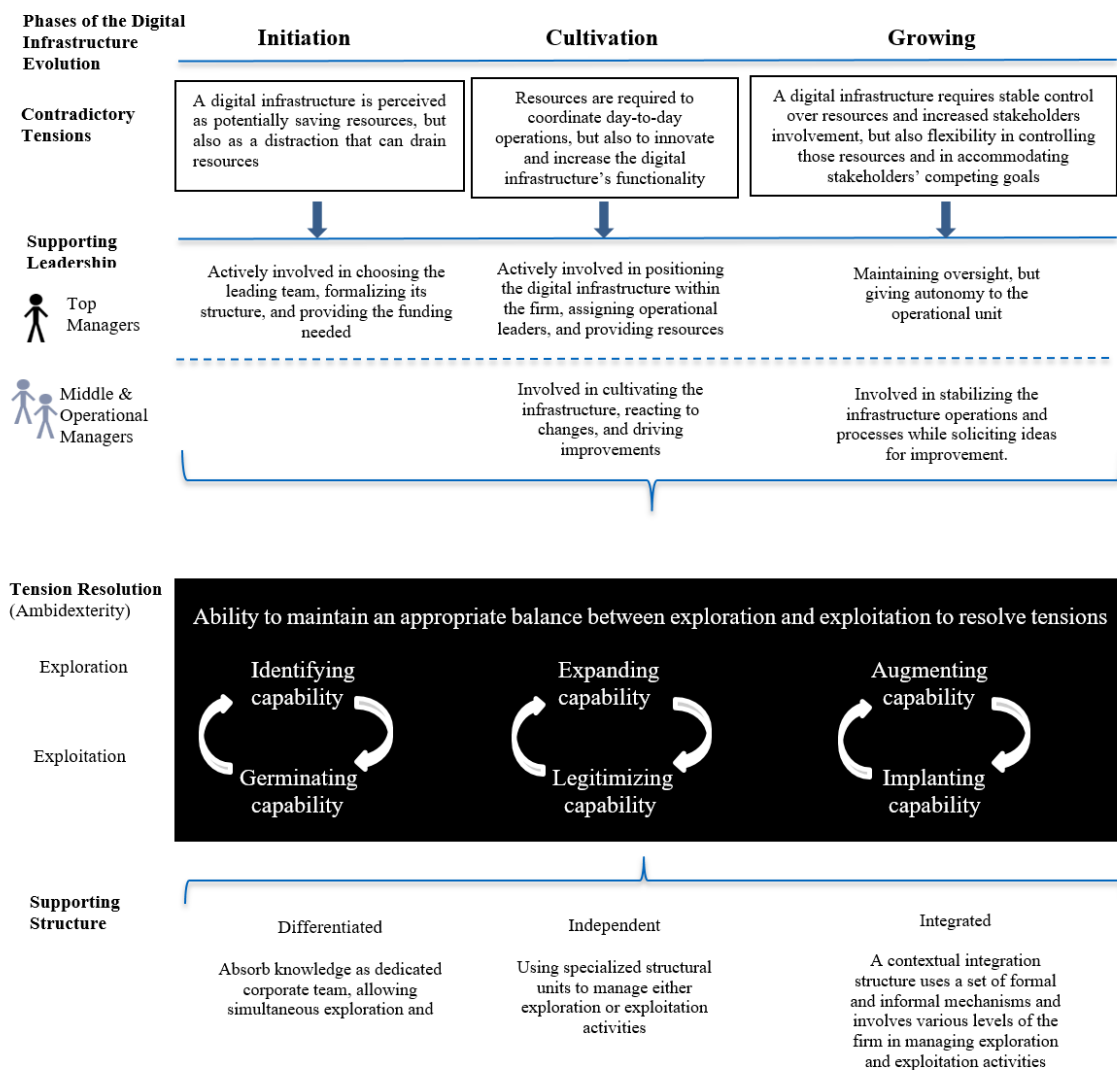

Figure 1. Theoretical Model of Ambidexterity in the Digital Infrastructure Evolution

In terms of structures, the model shows how these vary over time in supporting ambidexterity during the evolution of a digital infrastructure. In so doing, it sheds light on the findings of prior research, which has tended to focus on a single type of structure at a time to explain ambidexterity. For example, Bower and Christensen (1995, p. 44) state: "The only way to protect [new technologies] is to create organizations that are completely independent from the mainstream business". Conversely, others suggest that differentiated units are loosely coupled with a firm's mainstream units (Benner & Tushman, 2003; Duncan, 1976). Smith and Tushman (2005) explore how corporate teams achieve cross-fertilization between exploratory and exploitative activities. Others suggest that exploration and exploitation are carried out using integrated structures that have little structural differentiation (Adler, Goldoftas, & Levine, 1999; Gibson & Birkinshaw, 2004). Westerman, McFarlan, and Iansiti (2006) describe separate units that are linked to the mainstream organization through integration mechanisms at the business unit level, while Jansen et al. (2009) find a combination of structural differentiation at both corporate and business-unit levels.

In our case study, we observed different dynamics associated with balancing exploration and exploitation activities at each phase of the digital infrastructure evolution. We found that in the initiating phase of the digital infrastructure, when the expertise and skills required by the new infrastructure are limited, identifying and germinating capabilities, supported by a separate corporate team (differentiated structure) and actively involved top management, is essential. Accordingly:

Observation 1: In the *initiating phase* of a digital infrastructure, ambidexterity is driven by

a. top management setting up a differentiated corporate team with the required competencies and providing them with resources; and

b. a corporate team evaluating the new digital infrastructure (identifying) and also protecting the embryonic infrastructure when introducing it (germinating) to the firm.

In the cultivating phase, as understanding of the digital infrastructure's potential increases and its influence begins to be felt more widely across the firm, expanding and legitimizing capabilities, supported by two specialized operational units (independent structure) and a combination of actively involved top and middle managers, becomes central. Accordingly:

Observation 2: In the *cultivating phase* of a digital infrastructure, ambidexterity is driven by

a. top management changing the leadership of the digital infrastructure leadership from a differentiated corporate team to independent

operational units that pursue either exploration or exploitation; and

b. one of the units monitoring new opportunities and generating innovative ideas to increase the use and scope of the infrastructure (expanding), while the other oversees day-to-day tasks, establishes processes, provides targets, addresses problems, and handles external partners (legitimizing).

In the growing phase of the digital infrastructure's evolution, use of the infrastructure becomes a mature practice, is embedded in the structures and procedures of the firm, and involvement from its stakeholders increases. At this point, augmenting and implanting capabilities, supported by formal and informal structural mechanisms at different levels of the firm (integrated structure) and involvement from top, middle, and operational managers, are needed. Accordingly:

Observation 3: In the *growing phase* of a digital infrastructure, ambidexterity is driven by

a. top management maintaining oversight of the digital infrastructure, refining accountability, and tracking progress throughout the firm, while middle management integrates formal and informal structural mechanisms to cope with the competing demands arising from increased stakeholder involvement; and

b. integrating structural mechanisms used to keep the digital infrastructure from becoming outdated and determining how the digital infrastructure can produce even better results and extract more value in the future (augmenting). At the same time, these mechanisms are used to embed the infrastructure even further within the firm and make it an integral part of the firm's operations (implanting).

7   Implications

For researchers, this study responds to Tilson, Lyytinen, and Sørensen's (2010) call to examine new theoretical lenses by which we might understand the paradoxical nature of change in digital infrastructure evolution. Prior research has mainly focused on analyzing strategies that have proven to be effective in resolving contradictory tensions—such as adaptability (Hanseth & Lyytinen, 2010), structural centralization (Broadbent, Weill, & St.Clair, 1999; Ciborra et al., 2000), flexibility (Braa et al., 2007; Hanseth, Monteiro, & Hatling, 1996), governance models (Ure et al., 2009), and loosely coupled structures (Fabri, 2008). This study extends this stream of research by developing a conceptual integration of contradictory tensions and ambidexterity in order to understand how organizations balance exploration and exploitation to attend to contradictory tensions in the evolution of a digital infrastructure. Our study also extends the work

of Gregory et al. (2015) by articulating the organizational capabilities used to resolve the identified tensions over time—tensions that involved various levels of the organization. The contributions of our research lie in introducing the concept of digital infrastructure ambidexterity and proposing its underlying theoretical model. The model adds a dynamic perspective, allowing a disparate set of strategies to be tied together into a more coherent model that can serve as the basis for further investigation.

The study also has implications for the organizational ambidexterity literature. Although it is not possible to identify a universal set of capabilities (Teece, 2007), we identify that the distinctive sets of higher-order capabilities, as well as supporting leadership and structures, depend on the tensions that are present at each phase of the digital infrastructure evolution. Thus, we respond to recent calls for more insights into the nature of organizational capabilities required to achieve ambidexterity and more inductive research on how managers orchestrate the allocation of capabilities and resources between old and new business domains (Birkinshaw & Gupta, 2013; O'Reilly & Tushman, 2013; Raisch et al., 2009). Moreover, this study represents one of the first in-depth studies of ambidexterity embracing various levels of the organization over time. It employs an in-depth case study approach, where the focus is on discovering patterns of ambidexterity that emerge from "lived experiences" (Szulanski & Jensen, 2006). Our research also suggests that future research needs to move beyond from the reasonably well-developed understanding of how individual capabilities contribute to ambidexterity (Kale & Singh, 2007; Zahra, Sapienza, & Davidsson, 2006) toward understanding more about the interdependencies between the multiple capabilities that contribute to ambidexterity. For example, some authors suggest that structural separation is necessary, because each exploration and exploitation activity is completely different (Benner & Tushman, 2003; Duncan, 1976). Others recommend oscillating between these structures over time (Westerman, McFarlan, & Iansiti, 2006; Jansen et al., 2009) or argue that contextual ambidexterity brings about an environment in which every employee can decide whether to conduct exploration or exploitation (Gibson & Birkinshaw, 2004). We view both structural and contextual ambidexterity as being complementary options at RE/MAX, with each helping to resolve specific contradictory tensions at different phases of the infrastructure's evolution.

While this study should encourage and assist the pursuit of a more holistic understanding of ambidexterity in digital infrastructure evolution, further research is clearly needed in order to test the applicability of the model and observations in other contexts. In different firms, digital infrastructure ambidexterity may involve other contradictory tensions and require a different set of capabilities, resources, and activities. As our understanding grows, we may learn when (i.e., in what phase of the digital infrastructure evolution) specific activities will be most effective. For example, contextual ambidexterity may be counterproductive in an initiating phase when the firm lacks a clear vision of the infrastructure's potential. This point may question some of the factors traditionally identified as contributing to ambidexterity. Researchers might also conduct comparative studies across firms, industries, and countries to uncover how ambidexterity in digital infrastructure evolution may be enabled or inhibited by different contextual factors. This suggests the use of historical, cross-sector, or cross-cultural research designs.

For practitioners, this study also provides important lessons. Given today's dramatic and rapid advances in digital technology (computing power, data storage, and networks), organizations face the challenge of interconnecting system collectives (rather than stand-alone information systems). So, the importance of digital infrastructures will only increase. However, just jumping on the digital infrastructure bandwagon, without understanding the unique circumstances of the firm, is irresponsible and risky. Executives need to decide not just whether to join others in embracing a new digital infrastructure but, more importantly, how to keep renewing and refining it over time.

The study reveals the importance of understanding the broader contexts within which digital infrastructures are developed, identifying specific contradictory tensions, and managing the capabilities and supporting leadership and structures that help to balance exploration and exploitation activities at each phase of an infrastructure's evolution, instead of thinking about ambidexterity as a "one approach fits all" feature. The study also provides specific insights that organizations can use to:

- Reduce time in identifying/germinating during the initiating phase of a digital infrastructure evolution (for instance, by identifying members with complementary knowledge, undertaking global benchmarking, absorbing new knowledge as a separate group, crystallizing the objectives of the infrastructure, assessing the technological competence required, and establishing early funding to support adoption).

- Facilitate expanding/legitimizing in the cultivating phase of a digital infrastructure evolution (for instance, by leveraging complementary technologies and services found inside and outside the firm, establishing the infrastructure as part of the day-to-day operations, leveraging and co-opting technology and services from outside the firm,

legitimizing initiatives developed inside the firm, and establishing corporate funding to support expansion).

- Enable augmenting/implanting in the growing phase of a digital infrastructure evolution (for instance, by continuously identifying ways of integrating the digital infrastructure into the firm's operations, formalizing and integrating structural mechanisms to involve key stakeholders in further developing the infrastructure, investing in a stable technology base, and establishing a stable funding model).

An appreciation of the nuances of these insights, together with the process model of ambidexterity presented in Figure 1, can be used—either ex ante or ex post—to explain, anticipate, adjust, or evaluate the balancing act of managing the evolution of a digital infrastructure.

8 Conclusion

This study was motivated by the need not just to recognize how organizations experience and resolve contradictory tensions in the evolution of digital infrastructure, but also the need to learn about the organizational capabilities that drive the actions taken to resolve these tensions. The focus on recognizing these higher-order capabilities improves our

understanding of how organizations can find the delicate and shifting balance between exploration and exploitation activities in the evolution of a digital infrastructure. The key theoretical contribution of this paper is that it articulates the concept of digital infrastructure ambidexterity and develops its underlying theoretical model.

Our research approach has certain limitations that should also be considered. First, the findings are derived from the path taken at one specific organization. Nevertheless, because we have clarified the context and identified the capabilities and supporting factors that contributed to ambidexterity at RE/MAX, other researchers could adapt these insights and principles to a different context, and the proposed theoretical model and formulated observations could serve as a basis for further investigations (Miles & Huberman, 1994; Stake, 1995). Second, we followed prior research in studying ambidexterity and limited our analysis to two supporting factors (leadership and structure) in representing what Teece, Pisano, and Shuen (1997) refer to as previous paths and position of a dynamic capability such as ambidexterity. There may be other supporting factors for different paths that might impact the evolution of a digital infrastructure. Accordingly, future studies that expand the model presented in this paper may help to further our understanding of ambidexterity.

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Appendix: Description of MainStreet

MainStreet evolved from a stand-alone corporate extranet to a fully integrated agent- and broker-driven resource center that allows user customization. The platform is designed for flexibility and scalability to accommodate future technological needs and enhancements. It is built on the Microsoft SharePoint server and integrates with internal systems through common industry standards. This includes the membership management system, listing management system, lead management system, content management system, active directory, central email server, customer-facing website, and mobile applications. MainStreet also integrates with external vendor systems providing diverse content and services.

MainStreet services include:

Agent Profile: A personal page for agents to post and share professional details, including service area, listing sites, areas of expertise, awards, and industry designations.

Commercial Resource Center: Commercial data, statistics, and research for commercial real estate sales.

Design Center: On-demand design studio, containing more than 2,000 print and digital postcards, flyers, brochures, newsletters, video tours, and web commercials. May be personalized to individual needs.

Discussion Forum: Area for brokers and agents to ask questions, share knowledge, and comment on industry trends and events.

Download Center: Library of 50,000 digital files uploaded by RE/MAX headquarters, regions, offices, and sales associates. Contains educational material, business resources, and competitive intelligence targeted to broker owners and office managers, commercial agents, luxury home specialists, foreclosure sales and distressed property experts, and ecofriendly real estate specialists.

LeadStreet: Lead management dashboard which funnels potential clients to agents through the REMAX.com website.

Marketing Center: Legally approved images, logos, marketing claims, slogans, and latest ad campaign materials for radio, television, print, outdoor, and online marketing purposes. Provides a management tool to launch marketing campaigns via email, Facebook, Twitter, YouTube, LinkedIn, or Google+.

RE/MAX University: More than 1,200 on-demand training videos covering aspects of building a real estate business. Contains training pathways, training videos, agent/broker training on demand, off-site training, webinars, and technology training. Provides interactive tools for agents to develop learning plans and meet continuing education requirements. Content is provided by RE/MAX headquarters, external real estate training professionals, and high-performing agents invited to share best practices.

RE/MAX Weekly: Affiliate-focused news service and weekly email to keep agents abreast of the latest industry news.

Supplier Center: Connects agents to over 100 approved suppliers to purchase branded products, marketing materials, brochures, and magazines.

Technology Blog: Summary of popular technology trends, new software, and mobile apps. Contains archives detailing how to use new technologies to improve real estate business practices.

Travel Center: Full-service travel agency assisting affiliates with business travel needs.

Web Roster: Search and communication tool to support between-agent referrals. Facilitates referral fee negotiation and transfers relevant customer details between agents located anywhere in the world.

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