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GROWING PAINS: PRE-ENTRY EXPERIENCE AND THE CHALLENGE OF TRANSITION TO INCUMBENCY†

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We examine how entrepreneurial entry by diversifying and de novo firms in new industries leads to different levels of performance. We propose that these types of firms differ in dynamic capabilities, which help them overcome growth impediments and transition to incumbency in the industry. Growth impediments arise at larger size, older tenure levels in industry, and after technological discontinuities. Because of their prior experience, diversifying firms are better equipped to handle the challenges of impediments to growth. Meanwhile, de novo firms, ostensibly tailor-made for the targeted industry, are more likely to stumble over these growth challenges, and eventually lag behind diversifying firms. We find support for our hypotheses using a near census of firms in the U.S. wireless telecommunications industry over the 1983–2004 period. Copyright © 2011 John Wiley & Sons, Ltd.

INTRODUCTION

Studies of industry evolution largely sort firms along separate dimensions of incumbency and experience. Some studies focus on the survival of incumbents and entrants, extolling the virtues of entrepreneurial firms that displace incumbents (Christensen and Rosenbloom, 1995; Cooper and Schendel, 1976; Gort and Klepper, 1982; Henderson and Clark, 1990; Tushman and Anderson, 1986; Utterback, 1994). Other studies compare the performance of diversifying (pre existing firms in other industries) and *de novo* (new firms created in the focal industry context) entrants in a new industry (Bayus and Agarwal, 2007; Carroll *et al*., 1996; Ganco and Agarwal, 2009; Helfat and Lieberman, 2002; Holbrook *et al*., 2000; Klepper and Simons, 2000; Lane, 1989; Mitchell, 1991). Left unstudied, however, is the question of how pre-entry experience impacts diversifying and *de novo* entrants as they evolve and become incumbents.

Prior studies examining the static effects of pre-entry experience on survival have generally found a survival advantage for firms with pre-entry experience, though there are conflicting approaches and findings (Ganco and Agarwal, 2009). To the extent that researchers have considered dynamic patterns, the dominant models in economics (Klepper, 2002b) and organization studies (Carroll and Hannan, 2004) predict gradual convergence between diversifying and *de novo* firms. Convergence remains the dominant model, despite little empirical validation (Carroll *et al*., 1996) and even in the face of contradictory evidence (Bayus and Agarwal, 2007; Holbrook *et al*., 2000; Klepper, 2002a; Klepper and Simons, 2000).

Clearly the dynamic pattern of advantage between experienced and *de novo* firms merits

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more focused exploration. To study this dynamic, we examine how diversifying and *de novo* firms confront impediments to growth as they transition to incumbency in the industry. Harking back to an earlier tradition (Penrose, 1959), we treat growth as a primary challenge for firms as they evolve in the context of a focal industry (Caves, 1998; Sutton, 1997). Prior literature has identified three particular characteristics of incumbents (Acs and Audretsch, 1990; Gort and Klepper, 1982; Helfat and Lieberman, 2002; Tushman and Anderson, 1986)[1] that represent a serious impediment to growth: size (Penrose, 1959; Sutton, 1997), tenure in industry (Stinchcombe, 1965; Tripsas, 2009), and changing technology regime (Dowell and Swaminathan, 2006; Tushman and Anderson, 1986). Firms that successfully overcome these impediments—rising to incumbency in the new industry—must reconfigure existing operations (Karim, 2006) in order to plan and execute growth (Penrose, 1959).

We propose that *de novo* firms will have fewer integrative capabilities (Helfat and Raubitschek, 2000) and less transformational experience (King and Tucci, 2002) to draw upon than diversifying firms when they must integrate new resources to face these impediments. We test this prediction in the empirical context of the U.S. wireless telecommunications industry in 1983–2004, when a mix of *de novo* and diversifying firms raced to establish and grow service networks through a tumultuous period of growth and change. We find that size, tenure in industry, and technology regime change did, in fact, slow the growth of *de novo* firms more than they slowed comparable diversifying firms. Our results are consistent with the proposition that *de novo* entrants may be able to overcome inferior resources initially because their core knowledge better fits the new industry's needs (Helfat and Lieberman, 2002; Helfat and Raubitschek, 2000; Teece, 1986). However, *de novo* firms have less general experience (Teece, 1986), developed routines (Nelson and Winter, 1982), and integrative or transformational experience (Helfat and Raubitschek, 2000; King and Tucci, 2002) than diversifying firms, and this gap appears to exact a 'growth penalty' as they transition to incumbency.

By undertaking a study of growth of firms as they face the challenges of incumbency, we integrate firm and industry evolution and extend the literature in research streams in entrepreneurship, strategy, and organizational theory. In entrepreneurship, we highlight once again that established firms can be an important source of entrepreneurial activity when they enter new markets and compete in technology-intensive industries. Our analysis and findings stand in stark contrast to most theories of industry evolution, entrepreneurship, and strategy, which predict an initial advantage for diversifying firms that erodes over time (Carroll *et al*., 1996; Klepper, 2002a). Instead, the results are consistent with the widespread but little studied notion that growth is a particular challenge for entrepreneurial or *de novo* firms. In particular, the pattern of slowing growth in the face of impediments suggests that the capability to renew and reconfigure operations is one of the key deficits that *de novo* firms face in competition with firms that possess prior experience. This finding suggests that pre-entry experience helps diversifying firms develop superior dynamic capabilities (Carroll *et al*., 1996; Eisenhardt and Martin, 2000; Ganco and Agarwal, 2009; Teece, Pisano, and Shuen, 1997), engage in strategic renewal (Agarwal and Helfat, 2009), and successfully transition to incumbency. One of the essential tasks for future research, then, is to understand how firms transform experience into this ability, and whether the process can be accelerated through effective knowledge management.

THEORETICAL FRAMEWORK AND HYPOTHESES

Since the seminal work of Penrose (1959) and Nelson and Winter (1982), a rich line of research has focused on the importance of routines and path dependence in the persistence of heterogeneous firm capabilities and performance. Broadly, *de novo* and diversifying firms[2] differ in two

[1] This is also consistent with entrepreneurship literature, where the entrepreneurial or established firm distinction is based on size, firm tenure, and technological shocks (e.g., Agarwal, Ganco, and Ziedonis, 2009).

[2] We note that this definition relies on pre-entry experience at the firm level of analysis, rather than pre-entry experience of individuals/teams of individuals who found a firm or represent its top management team. Since founder pre-entry experience is an important determinant of heterogeneous capabilities and performance (Klepper, 2002a; Phillips, 2002; Agarwal *et al*., 2004), such *spin-out firms* could also be classified as possessing pre-entry experience, or at least a hybrid organization between the

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important dimensions: access to core knowledge specific to the industry (Helfat and Lieberman, 2002; Teece, 1986), and development of integrative knowledge (Hannan and Freeman, 1984; Helfat and Lieberman, 2002; Helfat and Raubitschek, 2000). While both types of knowledge have performance consequences, the latter type of knowledge is particularly important in terms of capabilities that help overcome impediments to growth, the focal issue examined in our paper.

We begin with a brief review of extant literature on the differences between *de novo* and diversifying firms and the anticipated impact of those traits on firm performance. We then develop our core theoretical proposition comparing the ability of *de novo* and diversifying firms when confronted with impediments to growth as they transition from entrants to incumbents. This leads us to hypothesize about how pre-entry experience interacts with size, tenure in industry, and change in technology regime leading to different patterns of growth.

Initial capabilities and performance after entry

Popular wisdom frequently credits *de novo* firms with being more focused and nimble, suggesting that they will outmaneuver their more experienced rivals and grow more quickly in new industries. *De novo* firms, by definition, start with a 'clean slate' and enter by configuring their resources to match the focal industry's competitive environment. Given their singular focus on this industry context, *de novo* firms can better cater to the demands of customers, suppliers, and other institutional players. Their core knowledge (Helfat and Raubitschek, 2000) is more likely to be suited to the technology and state of the market in the industry at time of entry. *De novo* firms can also leverage their flexibility to generate higher rates of new product innovations (Khessina and Carroll, 2008) and to avoid the myopic learning (Levinthal and March, 1993) and competency traps (Levitt and March, 1988) inherent to more established firms. Anecdotally, in the context of the semiconductor industry, Holbrook *et al*. (2000) describe how *de novo* firms Shockley and Fairchild Semiconductor, unfettered by past electrochemical technological and manufacturing traditions, chose entirely new technologies and experimented with alternative materials and processes. In the process, Fairchild Semiconductor coinvented and mastered the dominant design of the monolithic integrated circuit, in which all components are manufactured on a single piece of silicon.

Theory also suggests that diversifying firms might be more constrained and less flexible than *de novo* firms upon entering a new market. While diversifying firms often enjoy better resource endowments than *de novo* firms because they can leverage existing firm resources (Farjoun, 1998; Markides and Williamson, 1994; Miller, 2006; Teece *et al*., 1994), they typically must negotiate resource gaps because the new market requires a specific capability they lack, or because some pre-entry resources and capabilities are dysfunctional in the focal market (Helfat and Lieberman, 2002). This initial lack of fit to the focal industry context requires significantly more adaptation than *de novo* firms, which do not have to negotiate internal sources of inertia or have long-standing commitments to established value networks (Hill and Rothaermel, 2003). For example, while diversifying firms Sprague and Motorola brought related experience from electrochemistry into semiconductor manufacturing, they faced serious challenges as they developed hybrid circuits that could be used in conjunction with electrochemical transistors. In addition to the challenges of reconfiguring technological capabilities, both firms had to balance conflicting needs of existing and new customer segments and address managerial cognitive biases and coordination problems that arose due to differences in geographic locations of R&D and production (Holbrook *et al*., 2000).

Nonetheless, diversifying firms possess superior resource endowments from other markets, and have better access to financing, managers, technology, and relationships, (Carroll *et al*., 1996; Helfat and Lieberman, 2002; Klepper and Simons, 2000; Lane, 1989). Further, early diversifying firms can also influence the competitive landscape to better fit their own resources and capabilities (Carroll *et al*., 1996; Helfat and Lieberman, 2002; Klepper and Simons, 2000; Mitchell, 1991; Tripsas, 1997). For instance, IBM followed Apple and other *de novo* firms into the PC industry, but leveraged

two (Qian, Agarwal, and Hoetker, forthcoming). While acknowledging this issue, we retain the distinction at the firm-level unit of analysis since our interest is in examining the evolution of firm-level routines, capabilities and growth trajectories. *As a stand-alone firm*, spin-outs lack the experience of functioning in a competitive environment and producing goods and services (Helfat and Lieberman, 2002).

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its extensive core and complementary resources to ensure that DOS-based PCs became the dominant standard (Bayus and Agarwal, 2007; Steffens, 1994).

Empirical studies of diversifying and *de novo* firm advantages find patterns of performance and survival that match each of these theoretical stories. Ganco and Agarwal's (2009) literature review documents evidence for a diversifying firm advantage (Barnett and Freeman, 2001; Klepper and Simons, 2000), a *de novo* advantage (Agarwal *et al*., 2004; Khessina and Carroll, 2008), and a combination of the two (Bayus and Agarwal, 2007; Carroll *et al*., 1996; Hannan *et al*., 1998; Khessina, 2006; Klepper, 2002a). With these contrary expectations in mind, we make no prediction for the relative growth rates of the two types of firms when they are new entrants in the focal industry, and in the absence of impediments to growth. However, as both types of firm transition into incumbency, differences in their ability to undertake strategic renewal may result in performance differentials, an issue we now turn to.

Renewal ability of *de novo* and diversifying firms

The above attribution of potential diversifying firms' advantage to superior resource endowments ignores the potential value of a diversifying firm's integrative knowledge—its ability to reconfigure firm resources for new challenges or, as defined by Helfat and Raubitschek (2000), the knowledge of how to integrate different activities, capabilities, and products in one or more vertical chains. Integrating knowledge and activities across the firm is essential for strategic renewal.

To understand whether diversifying firms or *de novo* firms will be more capable of strategic renewal, we need to examine how their resources and capabilities enable or constrain integrative knowledge. In navigating the change to a new environment before or immediately after entry, diversifying firms amass integrative knowledge. They learn to scout and evaluate new market opportunities, for example, to integrate demand and technology signals and to restructure existing resources to enter a new market (Ganco and Agarwal, 2009; Helfat and Lieberman, 2002; Mitchell, 1989). By recombining firm resources to fit new problems and opportunities in the focal market, diversifying firms engage in bricolage (Baker and Nelson, 2005; Lévi-Strauss, 1967). Thus, diversifying firms are more likely to possess 'transformational experience' developed during their reorganization and redirection of effort to new markets (King and Tucci, 2002).

Carroll *et al*. (1996) assume that *de novo* firms have greater structural flexibility than diversifying firms, even though diversifying firms overcome inertial tendencies to enter a new industry. In contrast, we posit that superior integrative knowledge and transformational experience provides diversifying firms with a better ability to deal with the impediments to growth. In this sense, diversifying firms possess both structural and strategic flexibility (Volberda, 1996). Volberda (1996) defined structural flexibility as managerial capabilities for adapting an organization's structure and its decision and communication processes to suit evolutionary changes, and strategic flexibility as managerial capabilities that allow modification of goals in light of disruptive changes.

Holbrook *et al*. (2000) document the differences between the two types of firms when navigating changes in the semiconductor industry. *De novo* firms Shockley and Fairchild were able to leverage their initial fit for an early competitive advantage, but were less successful when changes rendered their core information advantage obsolete. At Shockley, for example, top management's focus on research and treatment of production as a subordinate turned into a disadvantage when managing the growing importance and complexity of production. Similar problems plagued Fairchild, which could not keep up with new competition and new technologies (Malone, 1985). In contrast, diversifying entrant Motorola's skillful management and coordination of R&D, production, and marketing enabled successful adaptation to market changes. Similarly, while *de novo* Fairchild initially led the way in the development of the integrated circuit dominant design, diversifying firm Texas Instruments—credited with coinventing the integrated circuit—ultimately outpaced Fairchild.

In sum, we believe that prior experience overcoming impediments to growth in other markets, and the transformative experience of entry into the focal industry, provides diversifying firms with more effective integrative knowledge. This integrative knowledge enables strategic renewal, and thus helps diversifying firms navigate the transition to incumbency in the focal industry better than *de novo* firms. In contrast to the

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mixed predictions for performance immediately after entry into the industry, this theory suggests an unequivocal advantage for diversifying firms as they face situations requiring strategic renewal, and particularly as they face the impediments to growth that arise in the transition to incumbency. This represents the foundational proposition of the paper.

Proposition: Diversifying firms are more capable of strategic renewal than de novo firms.

Transition to incumbency and impediments to growth

Separate from the research on *de novo* and diversifying firms, a rich literature on incumbent-entrant dynamics examines the challenges of incumbency in the face of 'creative destruction' represented by entrants (Agarwal and Gort, 1996; Christensen and Rosenbloom, 1995; Cooper and Schendel, 1976; Gort and Klepper, 1982; Henderson and Clark, 1990; Tushman and Anderson, 1986; Utterback, 1994). Notwithstanding a few exceptions (Bayus and Agarwal, 2007; Ganco and Agarwal, 2009; Methe, Swaminathan, and Mitchell, 1996; Sosa, 2006), this research stream largely lumps together both diversifying and *de novo* firms that enter the industry (Cooper and Schendel, 1976; Gort and Klepper, 1982; Henderson and Clark, 1990). No research, however, has examined how the two types of firms transition to the status of incumbent after entry.

While entrants are easily classified by appearance at a point in time, the status of incumbent is less distinct. In precise usage, incumbents are the established firms that exist when a new firm enters. In practice, when firms enter a market continuously, it is less clear which firms are 'established incumbents' at the time of entry since some existing firms will be other recent entrants. Theoretically, the concept of incumbency is closely related to the concepts of market power, resources, and legitimacy. Firms are accorded legitimacy, garner resources, and gain power as they spend more time in the industry, as they grow in size, and as they survive major transitions in the industry. Accordingly, incumbency status has been linked to three characteristics across literature streams in entrepreneurship, organizational demography, and industry evolution: firm size (Acs and Audretsch, 1990; Agarwal *et al*., 2009; Caves, 1998; Sutton, 1997) tenure in industry (Agarwal *et al*., 2009; Stinchcombe, 1965; Tripsas, 2009), and experience with prior technological regime (Dowell and Swaminathan, 2006; Tushman and Anderson, 1986).

These three characteristics of incumbents—size, tenure, and technological experience—also represent impediments to growth. Growth stresses the old system by threatening it with information overload or inconsistent activities. To accommodate the coordination and decision-making demands of growth, firms must socialize new members, extend routines, and reassign decision making to maintain consistency while still limiting the information and decision-making demands on existing managers (Penrose, 1959). Size, age, and technology regime experience amplify these challenges because they require reconfiguration of the firm's existing resource base (Karim, 2006; Karim and Mitchell, 2000; Penrose, 1959; Puranam, Singh, and Chaudhuri, 2009). As a result, diversifying and *de novo* firms negotiating the transition to incumbency must face impediments to growth by purposefully modifying their resource base. In the following sections, we explain why each characteristic of incumbency represents an impediment to growth, and we hypothesize that *de novo* firms—which have a relative disadvantage in the ability to renew the firm and modify their resource base—will grow more slowly than diversifying firms as they face the impediments.

The impediment of size

The effect of size on growth has occupied researchers since Gibrat proposed his 'law' that firms will grow at the same rate no matter their size (Gibrat, 1931). Penrose's seminal work (1959) argued that growth would peak for mid-sized firms and then fall for large firms. Since then, many studies have compared the growth rates of small and large firms. While the topic is still debated (Geroski, 1995; Sutton, 1997), studies that include private firms (Dunne, Roberts, and Samuelson, 1988, 1989; Evans, 1987a, 1987b) and that account for selection bias (Hall, 1987) generally find that small firms grow more quickly than large firms (Caves, 1998).

Large firms need well-developed systems for decentralized decision making to sustain creativity and entrepreneurship while reducing the demands on top management. Concurrently, these firms

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must provide information, incentives, and informal organization that ensure decisions do not clash across different functions, units, or levels of the company. Thus, size increases the challenge of growth because new techniques and practices are required to maintain the management system in the face of larger scale. Specific bureaucratic challenges arise for large firms in terms of adding additional resources and people. Top executives necessarily sacrifice the depth of information they can obtain about firm activities when the activities' breadth is large (Williamson, 1967). The administrative intensity of organizations is also higher for large firms, as they must devote proportionally more resources to monitoring and coordination (Caplow, 1957; Sutherland, 1980). The higher administrative intensity and controls in the firm will generally dampen incentives for entrepreneurial behavior. As a result of these challenges, new roles, structures, and practices must be created to maintain the coherent management system (Chandler, 1962; Stinchcombe, 1990).

In response to higher bureaucratic challenges, firms must reconfigure activities to maintain effective administration in the face of noisier information, weaker incentives, and rising complexity. Large firms must deploy integrative knowledge to recombine skills and knowledge held by the disparate members of the organization (Grant, 1996). The nature of administration across small and large firms becomes so radically different 'that in many ways it is hard to see that the two species are of the same genus' (Penrose, 1959: 19). The growth of the firm at larger sizes demands reconfiguration of firm resources to match the increased administrative challenges. Our core proposition that diversifying firms possess more developed capabilities for renewal then suggests:

> *Hypothesis 1: At larger sizes, de novo firms will face a larger growth penalty compared to diversifying firms.*

The impediment of tenure in industry

While size represents an impediment to growth because of the bureaucratic costs of growth, increased tenure or age in industry represents an impediment because of the challenge of inertia.[3] Tenure in the industry represents a growth challenge because historic industry-specific practices accumulate in an interdependent activity system; these practices create overlapping relationships within the firm that are difficult to alter. Once firms acquire the capital and social resources to launch operations, they tend to imprint powerfully with particular demands and structure of the extant environment (Stinchcombe, 1965). Organizations hold an imprint because the external environment demands consistent and reliable execution of the firm's mission, while internal organizational forces demand strong commitments to the firm's mission, core technology, and structure (Hannan and Freeman, 1984). For instance, firms that enter an industry before a dominant design emerges are significantly less likely to embrace that design (Dowell and Swaminathan, 2006). In addition, as firm tenure in the industry increases, their members increase their commitment to cultural scripts that dictate beliefs and actions concerning ways of doing things and the firm's mission (Harrison and Carroll, 2006). For example, Tripsas (2009) discusses the challenges faced by *de novo* firms over time as they navigate through identity and inertial pressures both within and outside firm boundaries. Evolutionary theories of organization suggest that these accumulated automatic behaviors, connections, and inertia have both benefits and costs (Nelson and Winter, 1982). In the context of growth, however, a firm's historic commitments and operations tend to increase the challenge of incorporating new resources and people.

These commitments increase the challenge of incorporating new resources because they represent an interdependent system of connections between activities and knowledge in the firm (Argote and Ingram, 2000). This interdependence makes it more costly and difficult to adopt new, complementary systems of production, such as the system of flexible manufacturing practices that arose in the 1980s and 90s (Milgrom and Roberts, 1990). In addition, the interdependence of activities makes knowledge transfer more costly within the firm (Rivkin, 2000) and between partners (Williams, 2007). These overlapping commitments

[3] As noted above, we define firm tenure to be 'time in focal industry' to maintain consistency across diversifying and *de novo* firms. Our arguments for time as an impediment to growth relate to focal industry environmental conditions and the accumulation of routines and commitments within the industry. Diversifying firms' efforts at altering existing capabilities to enter the focal industry implies a 'restarting of their clock' for a better fit with the focal industry conditions (Helfat and Lieberman, 2002).

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and connections mean that incorporating new people and resources in one area of the firm requires changes to other areas. Empirical studies also provide strong evidence that firm growth slows with age and tenure in an industry (Dunne *et al*., 1988, 1989; Evans, 1987a, 1987b; Sutton, 1997).

Beyond the focal industry context, it is true that diversifying firms are older and have existing commitments and activities from other industries. These prior commitments, however, will affect diversifiers' growth rate at entry. With increased industry tenure and concomitant transition to incumbency, we predict that *de novo* firms will struggle more with growth challenges even though they are younger in absolute terms than diversifying firms, because they possess less developed integrative knowledge. Specifically, diversifying firms have valuable prior experience managing interdependence, which is likely to make them more proficient at modularizing activities (Baldwin and Clark, 2000; Henderson and Clark, 1990) and are more likely to have administrative systems that can cope with increased complexity. Facing impediments from increasing age in the focal industry, we believe diversifying firms can deploy this integrative knowledge to manage interdependence more effectively than *de novo* firms. This leads us to hypothesize:

> *Hypothesis 2: At greater levels of industry tenure, de novo firms will face a larger growth penalty compared to diversifying firms.*

The impediment of technology regime

A change in technology regime represents a discontinuous shock to the industry that demands new configurations of organizational and managerial resources. This is also a key context within which the dynamics between entrants and incumbents have been studied. Technological shifts cause new entrant information to become more important (Gort and Klepper, 1982), require incorporation of new resources that conflict with accepted routines in the industry (Abernathy and Utterback, 1978), and devalue the existing resources of the incumbent firm (Tushman and Anderson, 1986). Firms may have a hard time perceiving that reconfiguration is necessary (Henderson and Clark, 1990), and even if they do so, face the innovator's dilemma given existing technological and demand commitments (Christensen, 1997). The critical impediment to growth in the face of a changing technical environment is the need to reconfigure the existing managerial system while incorporating novel resources and practices. Given that technological regime changes are often competence destroying (Tushman and Anderson, 1986), firms need to take stock of which competences to divest, and which ones still retain value. This is particularly hard if the external change renders core capabilities of the firm obsolete. Even seemingly small changes may require reconfiguration of embedded practices in ways that are difficult to perceive and react to (Henderson and Clark, 1990). Agarwal and Helfat (2009) document, in the case of the digital technology shock in the camera industry, that once dominant firms Konica and Minolta had to exit the industry. Even though Kodak survived the regime change, it faced significant hurdles in regaining part of its earlier market position. Similarly, Dowell and Swaminathan (2006) found that entrants to the bicycle industry were constrained by early technological choices: those that entered before the dominant design emerged had a hard time transitioning to the new design. Often the technological change is accompanied by changes in customer demand (Adner, 2002; Agarwal *et al*., 2004; Tripsas, 2009), requiring firms to undertake strategic renewal along multiple dimensions: business model, technological base, organizational structure, and organizational mindset (Agarwal and Helfat, 2009).

Within this context, diversifying firms can use their experience and integrative knowledge to react to the need for novel configurations when markets go through technology regime changes. Their transition from entrant to incumbency status when confronted with the impediment of a changing technological regime is enabled by their prior experience in negotiating such transformations in order to enter the industry, an experience that is lacking among *de novo* firms that are facing such a transition perhaps for the first time. In different industries, Bayus and Agarwal (2007) and Dowell and Swaminathan (2006) show that diversifying firms are better able to switch technologies after a dominant design is established than *de novo* firms. Accordingly, we argue that diversifying firms will better weather the discontinuous change relative to *de novo* firms. Thus,

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Hypothesis 3: After a shift to a new technology regime, de novo firms will face a larger growth penalty than diversifying firms.

In summary, we argue that size, tenure in industry, and change in technology regime represent important impediments to growth. As firms transition from entrants in the focal industry to become more established incumbents, their growth in the face of these impediments requires that they reconfigure management systems and informal organization so that they can maintain coherent and reliable behavior in the face of these changing demands (Nelson and Winter, 1982; Penrose, 1959). Diversifying firms possess more developed renewal capabilities through their experience in other markets and the experience of entering the focal market, so we hypothesize that *de novo* firms will incur a larger growth penalty in the face of these impediments.

It is important to distinguish this predicted advantage for diversifying firms from an overall growth advantage. All firms face limits to growth in any period (Penrose, 1959). We make no comparative prediction about the baseline growth rates of the two types of firms immediately after entry. Theory suggests many alternative endowments that diversifying firms possess that might give them a uniform advantage over *de novo* firms. Theory also suggests, however, that *de novo* firms are able to match their core operations more closely to the demands of the industry at the time of entry. Thus, we leave open the possibility that *de novo* firms will grow faster than diversifying firms when the firms do not face these impediments, that is, when the two types of firms are small, young in the industry, and founded in the current technology regime. Faster growth rates for *de novo* firms could arise in the absence of impediments to growth if *de novo* firms possess a flexibility advantage that allows them to match their core operations more closely to the competitive demands of the environment. The focus of our predictions, however, is that when both firms face impediments to growth, diversifying firms will face a smaller growth penalty than *de novo* firms.

Finally, size, tenure in industry, and changing technology regime are naturally highly correlated. Size and tenure tend to increase together, especially in an evolving industry with growing demand. In addition, increased tenure in industry will expose firms to more chances for a change in technology regime, so exposure to this change is likely to rise with tenure. Since we believe these are three specific instances of the more fundamental concept of an impediment to growth, we test for the effect of each separately, and then examine their joint effect.

EMPIRICAL CONTEXT AND METHODOLOGY

Industry context

We test our hypotheses using data from the U.S. wireless telecommunications industry from 1983 to 2004. Firms provide wireless radio communications services based on regional licenses from the Federal Communications Commission (FCC). The industry emerged in 1983, when Ameritech Mobile Communications launched the first commercial wireless telecommunications in Chicago. Fueled by the FCC granting hundreds of new licenses, the industry experienced significant entry and rapid growth in sales (number of cellular subscribers). Figure 1 depicts the number of wireless telecommunications firms in the industry and the total number of subscribers in each year. We include both composite data from the Cellular Technology Industry Association (CTIA) and the aggregate statistics for the firms in our sample. The trends conform to patterns documented in prior industry evolution studies (Agarwal and Bayus, 2002; Gort and Klepper, 1982). Additionally, the industry experienced a major discontinuous technological regime change from analog to digital transmission, which first entered the market in 1991 and took off around 1993.

Development and reconfiguration of capabilities for entry in the analog era of wireless communications

The 1984 FCC lottery selection process resulted in significant variation in the types of firms that entered the wireless communications industry. In addition to *de novo* firms, firms from related industries such as television, broadcasting, paging, and landline-telephones also offered wireless services. *De novo* firms developed their capabilities from scratch, investing in technical and operational capabilities, and several also engaged in alliances with firms related in the value chain. Many of

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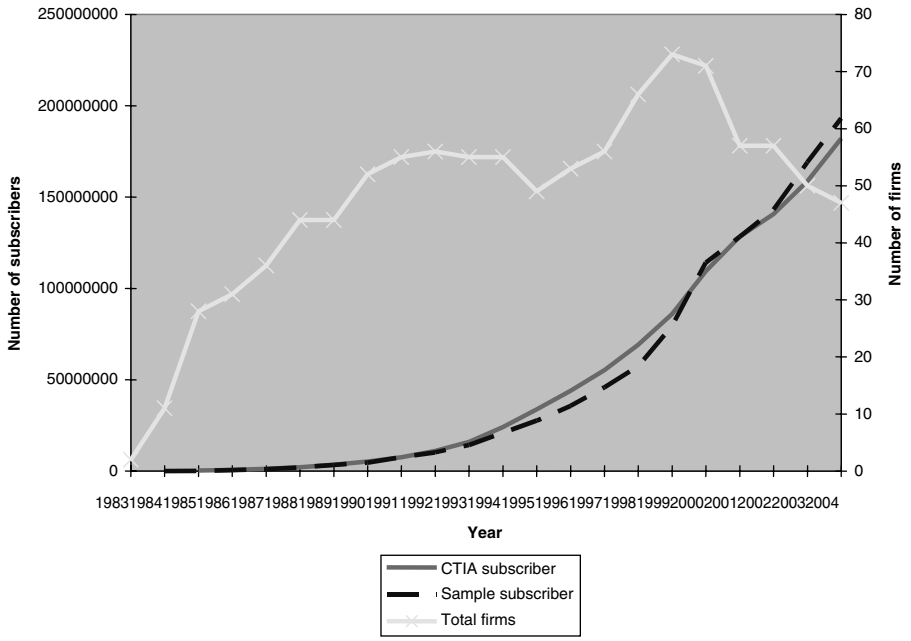

Figure 1. Industry subscribers and number of firms

the *de novo* firms showed the entrepreneurial flexibility that is broadly hailed in popular culture. For example, Nashville Cellular Telephone (NCT) competed by building a sales force that understood the new market's unique aspects, and tightly integrated billing, installation, and repair with its service. NCT's sales force was young and worked out of the trunks of their cars to sell to potential clients. On the corporate financing side, McCaw Cellular leveraged cash flow from each network acquisition to support more acquisitions using high yield debt (Corr, 2000).

Diversifying firms were both enabled and constrained by their existing capabilities, since they had to determine which capabilities had to be developed anew, and which could be reconfigured. Even the wireline telephone firms, with closely related pre-entry experience and resources, had to undertake significant capital investments at the time of entry, and sometimes address poor service reputation in their major telephone markets. They often found that their sales practices and incentives were less effective for popularizing the novel wireless phones. Diversifying firms had higher overhead costs, often twice as high as for many of the *de novo* firms. Additional reconfiguration issues related to understanding new patterns of demand. Pactel, for instance, tracked new subscribers but failed to follow the churn and exit of existing customers (Galambos and Abrahamson, 2002). Pactel also exemplifies the necessary managerial reconfiguration efforts. While many diversifying firms created new divisions to increase flexibility for new wireless operations, Pactel went so far as to temporarily transfer control of wireless operations from its corporate headquarters in California to the headquarters of an acquired wireless firm in Texas. These changes allowed the firm to develop managerial capabilities appropriate to the competitive wireless market, and created knowledge for renewal that the firm could draw on as it faced new challenges to growth.

Confronting impediments to growth and transition to incumbency

Firms that entered the wireless telecommunications industry had to engage in continuous strategic renewal to grow within the evolving industry as they transitioned to becoming incumbents. The industry's evolution and increase in demand were fueled by multiple incremental innovations and new business model developments, which collectively impacted key performance characteristics such as voice quality, range of coverage, interference of signal, and encryption for privacy. These innovations implied that firms confronted inertial

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pressures of the technology that they entered with, and had to engage in strategic renewal to stay abreast of the evolving technology.

Firms also engaged in other strategic renewal efforts as they exploited opportunities for increasing their customer base and coped with increasing competition. For instance, roaming agreements were key to increasing geographic scope and caller network base while staying price competitive. To enable subscribers to receive calls while traveling, firms needed to address the technical challenges of how to connect subscribers' handsets when they were in a partner's territory. Firms also needed to develop systems to record and appropriately bill/share revenues for such roaming calls. Other incremental innovations related to serving customer needs cost effectively, sometimes through the development of outsourcing agreements. Larger firms had to invest disproportionately in developing capabilities related to their subscriber base: some coordinated with external billing companies to handle the increased volume of subscribers, while others developed better internal capabilities related to automatic billing and credit checking systems. Indeed, as the wireless telecommunications industry matured, key success factors shifted away from reliability, technology, and interoperability and toward brand, reputation, and service. As a result, successful operators shifted from a business configuration in which technology and operations dominated decision making to one in which marketing and customer service dominated.

Transformation and reconfiguration of capabilities due to regime change to digital technology

The industry transition from analog to digital wireless telecommunications represented a major disruption that required firms to undertake significant reconfiguration and, thus, was an additional impediment to growth. Unlike the continuous signal of analog service, digital service converted speech into binary bits that improved performance characteristics and enabled more efficient use of the radio spectrum. Moreover, digital technology increased the scope of potential services from voice alone to images, music, and data (Calhoun, 1988; PR Newswire; Gruber, 2005).

Multiple challenges were encountered in the transformation to digital transmission. First, the industry was confronted with a 'war' where several standards (e.g., NAMPS, IS-45 TDMA, IS-136 TDMA, GSM, IS-95 CDMA) competed for dominance. Further, existing internal and external value chains had to be significantly restructured. Internal value chain restructuring required firms to alter equipment, reconfigure wireless transmission sites for optimal space allocation, develop rules for efficient and effective digital conversion, migrate customers from analog to digital service, educate sales force and reshape front-line operations to meet increasing demands for customer service. For example, the introduction of personal communication systems (PCS) digital technology required internal collaboration between a firm's assets management department and technical department to reconfigure radio sites due to the reduction of the size of transmission equipment. While analog technology required significantly more real estate to set up giant towers, higher-density PCS cell sites required significantly less space and could be placed inside a building. There was also significant variation in the rules used by firms for digital conversion. Bell Atlantic Mobile systems opened a new, $5-million regional operations center and switching facility in the University Research Park near Charlotte, North Carolina, and quadrupled call processing capability when converting to digital technology. Meanwhile, U.S. Cellular relied on an alliance with Numerex for expertise in migrating customers from analog to a digital network. In the context of front-line sales and customer service, AT&T Wireless introduced new retail outlets offering cellular phone and telephone service when converting to digital technology, and Ameritech opened 21 new 'One-Stop Communications Centers' in several states while rebranding its remaining 99 retail outlets as Ameritech Cellular Centers.

The technological regime change also caused significant changes in the external value chain of the industry, causing disruptions in existing partnerships and supply chain relationships as they related to technology sourcing, complementary products, and distribution channels. For example, to attract new subscribers and evolve its existing network, Vanguard Cellular Systems switched partners to work closely with Nortel and BNR for the switch and radio units that provided the flexibility of operations in both analog and digital mode. Firms often switched to new suppliers when existing suppliers were reluctant to move to digital technology, endorsed a different digital standard,

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or had lower digital technological capabilities. For instance, in spite of a long-standing relationship with Motorola, Nynex Mobile and Ameritech Corporation switched to Qualcomm (*Business Week*, 1990). Some firms forged new partnerships to offer products and services enabled by the digital technology, as when AT&T Wireless collaborated with Bloomberg Financial Markets to offer financial news for users of its PocketNet digital phone. Marketing agreements between Bell Atlantic Mobile and Comverge Technologies offered utility companies automated meter reading, environmental monitoring, energy management, and distributed generation monitoring services.

Thus, we believe the history of the wireless telecommunications industry makes it an ideal setting for our study: there was significant variation in the pre-entry experience of firms, a variety of incremental changes in both supply and demand characteristics representing opportunities and challenges for firm growth, and a major technological regime shift that required firms to undertake discontinuous transformation to survive and grow.

Data description

To obtain a comprehensive list of wireless telecommunications firms in the United States in each year from 1983 to 2004, we collected data from multiple sources, including annual directories published by Phillips Publishing, the FCC's *Universal Licensing System* (ULS), and industrial magazines and publications such as *Cellular Business, Cellular Radio: Birth of an Industry* (1983), *Cellular Marketplace* (1984) and *The Status of the Cellular Industry (1986–1992).* Additionally, we obtained relevant information on license ownership and licensees' activities from LexisNexis, company annual reports and 10Ks, and Donaldson, Lufkin and Jenrette Inc.'s *Cellular Communications Industry Report* (1985, New York).

To be included in our sample, we defined wireless telecommunications firms as firms that maintained *majority ownership* in a cellular phone license, purchased inputs such as communication equipment, and actually provided wireless communications service. This allowed us to rule out firms or individuals entering the industry solely to realize short-term gains from arbitrage, particularly as this occurred early in the industry when sales were very low. Our final dataset consists of an almost-census of the 77 wireless telecommunications firms for a total of 506 firm-year observations from 1983 to 2004. As depicted in Figure 1, the annual trend in subscribers attributable to sample firms closely matches the trend reported by CTIA.

Model specification and estimation

We test our hypotheses in an empirical growth model, which examines effects of explanatory variables on the annual growth of a firm's subscribers. Following the standard approach to growth models (c.f. Geroski, 2005), we define the natural logarithm of the growth rate (r) as

$$\begin{aligned}\mathrm{Ln}(r_{it}) &= \ln\left(\frac{subscribers_{it}}{subscribers_{it-1}}\right)\\ &= \ln(subscribers_{it}) - \ln(subscribers_{it-1})\\ &= \alpha + \gamma \ln(subscribers_{it-1}) + \beta X_{it-1} + \varepsilon\end{aligned}$$

where i denotes the firm of interest and t denotes the year, α is an intercept, X is a vector of other explanatory and control variables, β is a vector of estimated parameter values for those variables, and ε is an error term. To consider whether size affects the growth rate, our right-hand side equation includes lagged size, $\ln(subscribers_{it-1})$, with a parameter effect of γ. We consolidate the lagged variables on the right-hand side, thus our final growth model becomes the following:

$$\begin{aligned}\ln(subscribers_{it}) = \alpha + \ln(subscribers_{it-1}) + \gamma\\ \ln(subscribers_{it-1}) + \beta X_{it-1} + \varepsilon\end{aligned}$$

Gathering the lagged size terms together gives us:

$$\begin{aligned}\ln(subscribers_{it}) = \alpha + (1+\gamma)\\ \ln(subscribers_{it-1}) + \beta X_{it-1} + \varepsilon\end{aligned}$$

The coefficient of the lagged size variable, $(1+\gamma)$, is thus benchmarked at 1. For no effect of size($\gamma = 0$), the coefficient is 1; if larger firms grow faster than smaller firms($\gamma > 0$), the coefficient is greater than 1, and if vice versa, the coefficient is less than 1.

We estimate this model using a panel regression estimator with random effects to account for unobserved heterogeneity among the firms and Huber-White heteroskedasticity-consistent errors, clustered by firm (Table 2). To ensure robustness

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of results, we also analyze the effect of our variables of interest on the likelihood of exit (Table 3). For this model we use a panel complementary log-log estimator, as recommended by Allison (1982).

Dependent variables

Firm growth: Our central dependent variable, firm growth, is the increase in firm size, measured in total subscribers, over two consecutive periods. As described above in the model specification section, the dependent variable of firm growth is transformed into the logarithm of subscribers in a given year, with the lagged values of the variable collected on the right- hand side. Thus, the dependent variable in the analysis of firm growth is the natural logarithm of subscribers for firm i in year t, or $\ln(subscribers_{it})$.

Firm exit: As a robustness check, and given the widespread use of firm exit in studies that examine the relationship between pre-entry experience and performance (Bayus and Agarwal, 2007; Carroll *et al*., 1996; Klepper and Simons, 2000), we examine firm exit as an additional dependent variable. If a firm ceases independent operations in year t, the variable firm exit is coded as 1 that year, and 0 in the years between firm entry and year t. We note that firms rarely liquidate assets since the FCC licenses, along with other assets that they may have developed, retain value to the industry when bundled with operations. Accordingly, the chief mode of exit is by acquisition by another firm.

Key explanatory variables

The explanatory variables in our study relate to pre-entry experience, firm size, tenure in the wireless telecommunications industry, and technological regime.

De novo

Following prior literature, we define a firm as a *de novo* firm if it was founded in the wireless telecommunications industry, and as a diversifying firm if it operated in another industry prior to entering wireless telecommunications. Accordingly, the variable *de novo* is coded as 1 if the firm was a *de novo* and 0 otherwise. Among all the entrants, 25 percent were *de novo* firms.

Firm size

The growth model includes lagged size as an explanatory variable. This variable is computed as the natural logarithm of subscribers for the focal firm i in year $t-1$. Please refer to the section on model specification above for details regarding the interpretation of the coefficient.

Tenure in industry

Firm tenure in industry is measured as the years a firm has been in operation in the wireless telecommunications industry, and equals the difference between time t and entry year.

Entered in prior technology regime

This variable captures changes in the industry environment due to the discontinuous regime change from analog to digital. The variable '*entered in prior technology regime*' is coded as 1 if the firm entered the industry before 1991 and the year of observation is later than 1991 and zero otherwise; that is, it is coded as 1 if the firm entered during the analog era and is currently operating in the digital era and 0 if the firm operates under the same technology regime in use when it entered (analog or digital). The analog regime is defined as ending in 1991 when the first digital service is introduced. In robustness analysis we found little substantive difference in the results if we coded the transition as occurring in 1996, when service began in a new set of licenses issued by the FCC for digital service in a new part of the radio spectrum.

Control variables

We include several firm- and industry- level controls to account for both fixed- and time-varying effects. Our firm-level controls include firm year of entry to capture effects of imprinting at time of entry. Further, scholars in the industry evolution literature have identified evolutionary changes of two types: industry life cycle changes as they relate to increased standardization and development of the industry (captured by number of firms, industry sales, and growth), and disruptive technological change (as captured by technology s-curves and regime changes). While the latter is an explanatory variable of interest, we control for the effects of continual life cycle changes over time (and shifts

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of key success factors from reliability, technology and interoperability toward brand, reputation, and service) by including variables used in prior literature. These include the linear and quadratic terms for total number of firms in the prior year, the natural logarithm of all industry subscribers in the prior year (industry size), and the natural log of new industry subscribers added in the prior year (industry growth).

RESULTS

Quantitative evidence

Table 1 provides the descriptive statistics and correlation matrix. Results of the baseline specification, reported in Table 2, Column 1, are largely consistent with prior findings. The growth rate is higher for smaller firms than for larger firms, since the parameter for *size* is significantly less than 1, with a 99.9 percent confidence interval that excludes 1 in all the models.[4] In addition, firms with lower levels of industry tenure grow faster, as indicated by the negative and significant parameter for *tenure in industry. Entered in a prior technology regime* and *de novo* both have a nonsignificant negative effect on growth. The industry competitive environment does have an effect on growth, since growth falls with the number of firms in the industry (with a negative and significant effect of number of firms), but this effect diminishes as the industry expands (with a positive and significant effect of firms squared). Finally, the control variables for entry year, log of industry subscribers, and log of industry-subscriber growth do not have a significant impact on growth.

To test Hypothesis 1 (*de novo* firms face a greater reduction in growth than diversifying firms at larger size levels), we examine the interaction effect of *de novo* and *size*. Consistent with Hypothesis 1, Column 2, Table 2 shows that the coefficient for this variable is −0.076, which is significant at the 0.05 level. The simple effect of *de novo* is positive and marginally significant,

Table 1. Descriptive statistics and correlation matrix

		Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Size	12.71	1.98	7.22	17.71	1.00									
(2)	Tenure in industry	6.08	4.37	0	19	0.52	1.00								
(3)	Entry year	1989.03	5.31	1983	2002	0.05	−0.48	1.00							
(4)	Number(#) of firms	42.49	6.05	24	53	0.26	0.22	0.29	1.00						
(5)	Number(#) of firms, squared	1842.12	498.68	576	2809	0.25	0.2	0.29	0.99	1.00					
(6)	Log(industry subscribers)	16.95	1.61	11.56	18.95	0.5	0.38	0.61	0.62	0.59	1.00				
(7)	Log(growth industry subscribers)	15.58	1.24	11.47	17.36	0.49	0.37	0.59	0.65	0.62	0.98	1.00			
(8)	Firm size, lagged	12.27	2.15	5.70	17.44	0.98	0.56	0.04	0.26	0.24	0.52	0.5	1.00		
(9)	*De novo*	0.23	0.42	0	1	−0.15	−0.23	0.26	0.01	0.01	0.06	0.06	−0.15	1.00	
(10)	Entered in prior technology regime	0.39	0.49	0	1	0.26	0.61	−0.49	0.27	0.25	0.09	0.11	0.28	−0.19	1.00

[4] To formally test that the true value is not 1—given the 'unit root problem' that random walk changes in a panel cannot be identified by the standard t-test for differences in parameters—we conducted unit root tests for panel data as recommended by Hall and Mairesse (2005) and Bond, Nauges, and Windmeijer (2005), and were able to reject the null hypothesis of unit root (test statistic = 50.13; p-value = 0.00001) for our model.

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Table 2. Growth model with moderating effects of tenure in industry, size, and technology regime for *de novo* and diversifying firms

		(1)	(2)	(3)	(4)	(5)
Tenure in industry		−0.080*	−0.084*	−0.096**	−0.081*	−0.086*
		(0.047)	(0.046)	(0.046)	(0.047)	(0.045)
Entry year		−0.073	−0.075	−0.077*	−0.073	−0.075
		(0.047)	(0.046)	(0.046)	(0.047)	(0.045)
# of firms		−0.13**	−0.13**	−0.13**	−0.13**	−0.13**
		(0.062)	(0.062)	(0.062)	(0.062)	(0.062)
# of firms, squared		0.0015**	0.0015**	0.0015**	0.0015**	0.0015**
		(0.00066)	(0.00065)	(0.00066)	(0.00066)	(0.00065)
Log(industry subscribers)		0.18	0.20	0.19	0.18	0.20
		(0.21)	(0.21)	(0.21)	(0.21)	(0.21)
Log(growth industry subscribers)		0.14	0.13	0.13	0.13	0.13
		(0.085)	(0.083)	(0.085)	(0.085)	(0.083)
Firm size, lagged		0.87***	0.84***	0.87***	0.87***	0.85***
		(0.024)	(0.026)	(0.024)	(0.024)	(0.032)
Entered in prior technology regime		−0.033	−0.034	−0.035	0.00075	−0.022
		(0.053)	(0.050)	(0.051)	(0.055)	(0.054)
De novo		−0.028	0.86*	0.11	0.012	0.77
		(0.071)	(0.44)	(0.11)	(0.078)	(0.55)
De novo × firm size, lagged	H1		−0.076**			−0.066++
			(0.035)			(0.051)
De novo × tenure(age) in industry	H2			−0.034**		−0.0047++
				(0.014)		(0.020)
De novo × prior technology regime	H3				−0.18**	−0.070++
					(0.081)	(0.099)
Constant		145	149*	153*	146	150*
		(93.0)	(90.0)	(91.1)	(92.0)	(89.3)
R-SQUARED		**0.959**	**0.960**	**0.960**	**0.959**	**0.960**

(Random effects model; robust standard errors clustered by firm; outcome is natural logarithm of subscribers year t; independent variables measured at prior year end; Size coefficient less than 1.0 indicates small firms grow faster and significance for this parameter is tested for difference from 1.0; n = 502; firms = 76; random effects R-squared not bounded by 1).
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
++ jointly significant at $p < 0.05$.

which suggests that *de novo* firms actually grow more quickly than diversifying firms when both are small. Figure 2 illustrates the contingent effects of size on growth rates for diversifying and *de novo* firms by graphing predicted values using Clarify (King, Tomz, and Wittenberg, 2000; Tomz, Wittenberg, and King, 2001).[5] Growth rates for observed *de novo* firms are represented by Xs while growth rates for observed diversifying firms are represented by Os. The graph shows that the expected growth rates for *de novo* firms at small sizes are larger than for diversifying firms. The two growth curves cross at a log size of about 12.2, indicating that diversifying firms outpace *de novo* firms beginning at a size of 200,000 subscribers(just below the fiftieth percentile of the size distribution).

To test Hypothesis 2 (*de novo* firms face a larger decrease in growth with increased industry tenure as compared to diversifying firms), we examine the interaction effect of *de novo* and *tenure in industry*. Consistent with Hypothesis 2, Column 3, Table 2 shows that the coefficient for this variable is −0.034, which is significant at the 0.05 level. The simple effect of *de novo* is not statistically significant. Figure 3 illustrates this effect by graphing the predicted growth rate of *de novo* and diversifying firms for each observed value in the sample. At low levels of tenure, *de novo* firms begin with growth rates similar to diversifying firms but gradually fall lower due to the differential growth penalty as tenure increases.

[5] Clarify generates values of interest based on simulation of the estimation uncertainty of the parameter values as well as the fundamental uncertainty from the estimated error term. The graph shows an expected growth rate for each observation in the sample based on the average of 1,000 simulations using Clarify.

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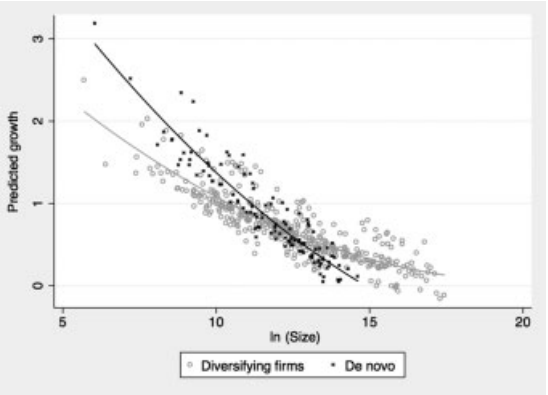

Figure 2. Predicted growth for *de novo* and diversifying firms over size. (Graph based on average of 1,000 simulations of Model (2) from Table 2 using clarify module for Stata. The lines are quadratic fitted lines based on the simulated data)

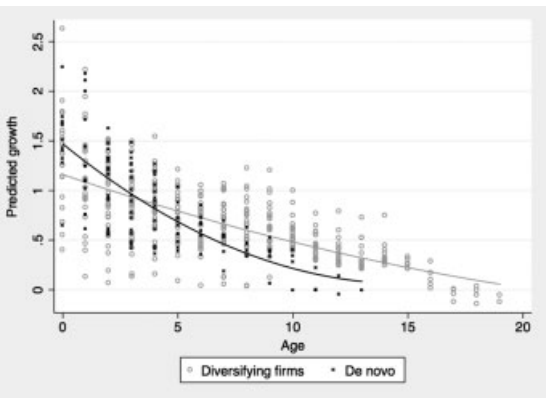

Figure 3. Predicted growth for *de novo* and diversifying firms over industry tenure. (Graph based on average of 1,000 simulations of Model (3) from Table 2 using clarify module for Stata. The lines are quadratic fitted lines based on the simulated data)

Finally, to test Hypothesis 3 (*de novo* firms face a higher growth penalty than diversifying firms after they have transitioned to a new technology regime), we examine the interaction effect of *de novo* and *entered in prior technology regime*. Consistent with Hypothesis 3, Column 4, Table 2 shows that the coefficient for this variable is −0.18, and significant at the 0.05 level. Unlike the prior interaction terms, which involved continuous variables, this interaction is a simple shift parameter since *de novo* and *entered in prior technology regime* are both categorical 0/1 variables. Figure 4 illustrates the lower growth that *de novo* firms face

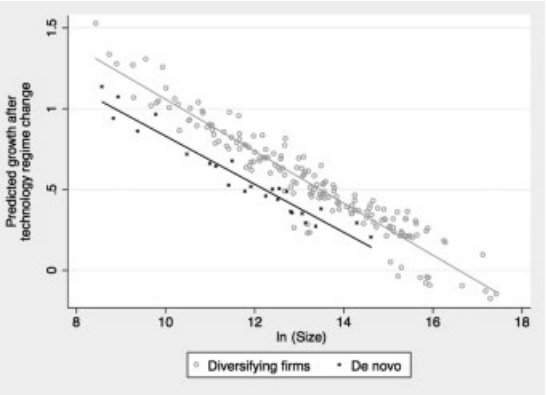

Figure 4. Predicted growth for *de novo* and diversifying firms after technology regime change. (Graph based on average of 1,000 simulations of Model (4) from Table 2 using clarify module for Stata. The lines are linear fitted lines based on the simulated data)

after a technology regime change, relative to comparable sized diversifying firms.

Column 5, Table 2 examines the joint effect of the three interaction effects. The coefficients for the interaction effects are all negative and are jointly significant at the 0.05 level based on a Wald test, consistent with our proposition that diversifying firms will face a lower penalty in the face of impediments. We note though, that, none of the coefficients are individually significant in Model 5 due to high multicolinearity. Thus, the analysis cannot separately identify which variable is most important in constraining the growth of *de novo* firms, or whether some but not others are causing the growth penalty. Since our focus is the differential response of *de novo* and diversifying firms to growth impediments, and not the differential impact of specific impediments to growth, this uncertainty is not material to our core findings.[6]

Corroborating qualitative evidence

Qualitative evidence from firm histories corroborates the above quantitative results.[7] Relating to

[6] We note that our theoretical interest is in examining the interaction effect of pre-entry experience on the impediments to growth. Size, tenure in industry, and technological regime change represent a *group* of variables that collectively contribute to growth impediments. Wooldridge (2002) discusses why a joint test of significance is more appropriate than examining the t statistics for individual significance in such a situation.

[7] The cases are intended as examples that illustrate and reinforce what the quantitative analysis already shows, and not as standalone unbiased evidence from rigorous qualitative methodology.

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Hypotheses 1and 2, among the *de novo* firms, a salient example is Metro Mobile; the practices that helped grow the firm when it was small and new to the industry also hurt it when it became large and more established. When small and young, Metro Mobile's aggressive growth strategy included offering sales agents an incentive of $300 for each new subscriber. However, this strategy backfired later and at a larger size: new subscribers were often family members of existing customers, and the lighter use of the secondary lines resulted in Metro Mobile often taking four years to recoup the original commission (Ramirez, 1991). Similarly, *de novo* Western Wireless was one of the fastest growing firms shortly after its entry in 1992 due to aggressive purchases of PCS licenses. Later and at a larger size, the costs of acquiring additional rural cellular and PCS licenses took a heavier toll on the company, leading to losses incurred from high interest costs and financing expenses.

The diversifying firms, in contrast, seemed to handle the impediments of larger size and tenure in industry better than the *de novo* firms. U.S. Cellular for example, was able to sustain its growth rate as it gained tenure in the industry, and at larger sizes, by simultaneously deepening existing distribution channels among its primary subscriber base—the business users—and creating more breadth by expanding service to consumers for everyday use. Instead of solely relying on its direct sales team, U.S. Cellular converted some of its office locations into retail stores, and arranged for kiosks at Walmart to help reach consumers directly (St. James Press, 2000–2004). Dobson Communications, another diversifying firm initially experienced low growth rates, in part because the wire-line firm did not develop its cellular systems rapidly after its first acquisition of small and regional cellular systems in Oklahoma and the Texas Panhandle. However, subsequent aggressive acquisition strategies in the late 1990s helped it grow beyond its southwestern roots to create a presence in the eastern United States. Later and at a larger size, Dobson Communications continued to successfully expand to Texas and California. Among its most notable acquisitions was American Cellular Corporation (initially jointly controlled with AT&T, and later solely owned). Dobson recorded robust growth in the twenty-first century and through the end of the sample period (St. James Press, 2000–2004). Yet another prominent example is Century Communications, which experienced increasing growth rates at larger sizes and increased tenure due to its strategy of gradually integrating the cellular operations with its operations in related industries of cable TV and other communications technologies to provide a streamlined and interactive, multimedia network (St. James Press, 2000–2004).

When confronted with a discontinuous technological change, the strategic response of *de novo* and diversifying firms were quite different, resulting in differences in growth rates (Hypothesis 3). While a new digital technology code division multiple access (CDMA) was pioneered by a diversifying firm Pactel, the largest *de novo* firm, McCaw Cellular, actively lobbied against it (St. James Press, 2000–2004; Ramirez, 1993). Pactel invested significant resources in digital technologies, helped the global standard for mobile communication (GSM) become a standard across multiple countries, and partnered with companies like UPS to increase diffusion. Pactel ultimately transformed itself into AirTouch to focus exclusively on digital wireless communications including cellular, paging, vehicle location, and wireless data services (St. James Press, 2000–2004). Meanwhile, McCaw Cellular Communications lobbied against CDMA digital technology. While acknowledging that it might use the technology someday, the firm believed that several serious technical problems had not been resolved (Corr, 2000; Ramirez, 1993). *De novo* Western Wireless struggled with the challenges of managing both analog and digital operations under the same corporate umbrella, and chose to spin off the digital operations into a subsidiary venture, VoiceStream. When Western Wireless ultimately exited in the 1990s, it did so without the fast-growing VoiceStream business (St. James Press, 2000–2004). In stark contrast to the strategy of Western Wireless, diversifying firm Sprint chose to divest its analog operations and instead focus on the digital PCS technology, in spite of analysts' cautionary notes that the unproven PCS service would require high expenditures (*New York Times*, 1995). Not surprisingly, these anecdotes illustrate the willingness of diversifying firms that had already undergone significant transformation and reconfiguration of capabilities to enter into the wireless communications industry,

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Table 3. Exit from wireless telecommunications industry for *de novo* and diversifying firms with moderating effects of tenure in industry, size, and technology regime

		(1)	(2)	(3)	(4)	(5)
Tenure in industry		−0.019	0.078	0.043	0.068	0.098
		(0.743)	(0.782)	(0.746)	(0.761)	(0.804)
Year of entry		−0.161	−0.048	−0.073	−0.111	−0.080
		(0.754)	(0.79)	(0.756)	(0.767)	(0.808)
# of firms		0.161	0.057	0.248	0.198	−0.005
		(0.965)	(1.006)	(0.973)	(0.976)	(1.026)
# of firms, squared		0.000	0.001	−0.001	−0.001	0.002
		(0.010)	(0.011)	(0.010)	(0.010)	(0.011)
Log(industry subscribers)		1.675	1.117	1.326	1.472	1.233
		(3.037)	(3.160)	(3.049)	(3.081)	(3.230)
Log(growth industry subscribers)		−1.543*	−1.280	−1.474*	−1.429*	−1.187
		(0.856)	(0.875)	(0.862)	(0.864)	(0.884)
Firm size, lagged		−0.057	−0.072	−0.053	−0.068	−0.083
		(0.106)	(0.113)	(0.105)	(0.111)	(0.125)
Entered in prior technology regime		0.693	−0.622	0.695	−1.413*	−1.514
		(0.613)	(0.616)	(0.601)	(0.843)	(1.082)
De novo		0.217	−0.347	−0.933	−1.090	−1.223
		(0.404)	(0.548)	(0.836)	(0.791)	(0.954)
De novo × firm size, lagged	H1		1.22e-06**			1.13e-06**++
			(4.95e-07)			(5.12e-07)
De novo × tenure(age) in industry	H2			0.173*		−0.087++
				(0.100)		(0.152)
De novo × entered in prior technology regime	H3				2.307**	2.719**++
					(1.082)	(1.489)
Constant		307.481	89.893	134.897	208.016	150.982
		(1478.232)	(1549.738)	(1483.275)	(1503.512)	(1585.729)
Log likelihood (Wald chi2)		27.47 (0.0012***)	31.25 (0.0005***)	30.53 (0.0007***)	24.18 (0.003***)	27.76 (0.006***)

(Outcome = Exit the market (acquisition); Information at coefficient on *de novo* >0 indicates the probability of exiting the market by *de novo* firms compared to diversifying firms; n = 560; firms = 77; total exits = 41; robust standard errors in parentheses; Random-effects complementary log-log model; when size data was missing the year before exit, most recent size observation was substituted).

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

++ jointly significant at $p < 0.05$.

to be more proactive and embracing of digital technology relative to the *de novo* firms that struggled with the challenges of such a transformation.

Robustness of analysis

To check the robustness of our results, we examined market exit as an alternative dependent variable. Results are displayed in Table 3, and the five columns of the table replicate the five models shown the columns of Table 2. Consistent with the findings of the analysis of growth among these firms, the exit analysis shows that *de novo* firms have an increased likelihood of exit in the face of the impediments to growth. Model 2 in Column 2 shows that *de novo* firms have an increased risk of exit at larger size levels, and this effect is significant at the 0.05 level. In Model 3, *de novo* firms are more likely to exit the industry compared to diversifying firms at higher levels of industry

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tenure, though this effect is marginally significant at the 0.10 level. In Model 4, *de novo* firms are significantly more likely to exit the industry after they have experienced the industry shift from analog to digital technology standards. In addition, the three effects are jointly significant at the 0.05 level in Model 5, and the effects of size and change in technology regime remain individually significant as well. Tenure in industry appears to have a weaker effect on exit than the other two impediments, because the parameter estimate becomes negative, though nonsignificant, in the joint model. Overall, however, the impact of impediments on exit very closely matches the pattern of their effects on growth and is, if anything, more significant in the exit analysis.

We also conducted various checks to examine sensitivity of our analysis and rule out potential alternative explanations. The following robustness analyses are not reported in tables due to space constraints, but are available upon request from the authors. A significant robustness check of our growth model was to estimate it using the generalized method of moments (GMM) system estimators for panel models (Arellano, 2003; Blundell and Bond, 2000; Bond, 2002). While the approach is not without limitations,[8] it is useful in regressions that include a lagged value of the dependent variable, since any firm-level heterogeneity will bias the ordinary least squares estimate of the lagged value upward.[9] The estimates of the interaction of *de novo* with instrumented values for the size variable remain negative and significant at the 0.05 level. We also test the sensitivity of our results for alternative values of the dummy variable for *entered in a prior technological regime*. It could be argued that when digital technology was first introduced in 1991, the industry did not immediately switch to digital. The results are substantively similar for alternative coding of the transition year through 1996, which marks the new set of digital licenses issued by the FCC for a new part of the radio spectrum.

An important alternative explanation relates to the 'resource-richness' of diversifying firms. Resource advantages, particularly related to deep financial pockets, may cause differentials in growth and exit rates, rather than the integrative knowledge that helps in strategic renewal. First, we note that resource richness should cause a uniform growth advantage or growth advantages at *smaller* levels of size and tenure in industry, rather than one that increases with these factors. Thus, our findings for the opposite effect run contrary to resource richness being the main driver. Second, we explicitly test for whether resource-rich diversifying firms grow faster because of investments made to acquire other firms and gaining ready-made subscribers. In robustness checks, we removed subscribers that were added through acquisitions. The results for this analysis were almost identical to the results reported in Table 2. Thus, we conclude that acquisitions are not the primary factor in higher growth rates for diversifying firms in our sample.

It is also possible that the results are driven by mode of entry choices by the diversifying firms coming into the market. That is, outside firms enter the market as a coherent organizational entrant—thus appearing as diversifying firms in our study—when they anticipate slower initial growth requiring more sustaining resources from the parent, and they enter as a spin-out formed by departing executives from the related firm—thus appearing as *de novo* firms in our study—when they anticipate rapid initial growth that will not require resources from the parent. As a robustness check, we exclude six spin-out firms—*de novo* firms with founding executives from a related industry—from the analysis and the results are not substantively different from those reported in Table 2. As an additional check, we exclude two spin-off firms—those divested from diversifying firms—from the analysis and find no difference in the results. Finally, we note that our control variables capture much of the general effects of industry evolution and competition, since the number of firms, industry sales, growth in sales, and year of entry dummies are all included in the analysis. Consistent with prior literature, we do find that increased competition results in lower overall growth rates, but the other variables do not have a main or interaction effect on growth rates.

[8] This approach uses further lags of the dependent and independent variables in the regression to instrument for current values. Shortcomings of the approach include the following: The lagged instruments have no prior theoretical justification for why they should be uncorrelated with the error that is presumed in the relationship between the values at t and t − 1. In addition, instrumental variable GMM estimators are known to have poor finite-sample estimation properties with large numbers of instruments, as in the case of some specifications of this estimator for our model, which involved over 200 instruments.

[9] We note that this biases the effect of size in Table 2 toward 1, in the opposite direction of our predicted relationship, implying that our test is conservative.

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DISCUSSION AND CONCLUSIONS

This paper examines how diversifying and *de novo* firms in a new industry differ in their performance over time. We propose that diversifying firms possess a greater ability to modify and reconfigure their resource base, which enables them to overcome growth impediments and, ultimately, transition to incumbency in the industry. Thus, the patterns of growth and adaptation in the wireless industry clarify the endowments and constraints that arise from pre-entry experience. Rather than finding a general resource or core knowledge advantage for diversifying firms that fades with time, we find that the performance of diversifying and *de novo* firms *diverge* over time as they encounter impediments that require them to change. This suggests that one of the key endowments that experienced firms bring to a new industry is the ability to modify their existing resources.

Theoretically, this contrasts with the generally accepted models of pre-entry experience. In both economics (Klepper, 2002b) and sociology (Carroll *et al*., 1996), the dominant models predict that entrants with prior experience will possess an initial advantage, which erodes with time. This predicted pattern remains firmly entrenched despite the lack of supporting evidence. Table 4 lists papers that have studied the interaction of pre-entry experience and various impediments to growth associated with the transition to incumbency. While three studies have predicted convergence for the two types of firms as they age, none of them have found support for this prediction—and in several instances have found evidence of actual divergence. In addition, the three studies that have predicted divergence of the two types of firms have found evidence consistent with the prediction. In sum, the field has favored the convergence model despite significant evidence to the contrary.

Prior studies have found contradictory evidence when comparing the advantages of *de novo* and diversifying firms or incumbents and new entrants. While some studies find performance advantages for new entrants (Christensen and Rosenbloom, 1995; Cooper and Schendel, 1976; Tushman and Anderson, 1986; Utterback, 1994), others find advantages for incumbents (Christensen, Suarez, and Utterback, 1998; Katila, 2002; Madsen and Walker, 2007; Mitchell, 1989, 1991; Tripsas, 1997). Similarly, some studies find performance advantages for *de novo* firms (Agarwal *et al*., 2004; Khessina and Carroll, 2008), while others find performance advantages for diversifying firms (Carroll *et al*., 1996; Klepper and Simons, 2000). These contradictions might be resolved by focusing on dynamic rather than static comparisons of the different types of firms. Since these studies do not simultaneously incorporate both pre-entry experience and transition to incumbency, they may find these different main effects because of omitted variable bias. In addition, they may find different average effects because the timing of the transition to incumbency varies across industries, perhaps due to different rates of growth or technological change.

In contrast to the conventional model, we observe diversifying firms diverging from *de novo* firms as time goes by. Compared to diversifying firms, *de novo* firms suffer a higher performance penalty as they transition to incumbency. *De novo* firms that are larger, older, and have transitioned to a new technology regime grow more slowly than similar firms with pre-entry experience (diversifying firms). For survival, the same pattern holds true, with experienced firms facing a smaller increase in exit rates as they transition to the status of incumbent. In terms of both growth and survival, then, the advantages of experienced over *de novo* firms actually increase rather than fade.

We attribute this divergent growth to the integrative knowledge developed by diversifying firms as part of their pre-entry and early entry experience. Diversifying firms appear to develop the ability to modify their resource base through the process of entering a new market and managing the complexity of multiple markets. Thus, our findings parallel Holbrook *et al*.'s (2000: 1033) conclusion from the semiconductor industry that 'the most important capabilities are ones that enable a firm to adapt to technological and market change over time.' In addition to the challenge of external change, our study highlights the importance of the internal changes that a firm must navigate as it faces the challenges of bureaucracy and inertia from size and age.

It might be argued that resource advantages, particularly related to deep financial pockets, cause diversifying firms to grow faster by *acquiring* other firms and gaining ready-made subscribers. This argument ignores evidence that acquisitions

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Table 4. Prior studies exploring interaction of pre-entry experience with impediments to growth

Study	Industry	Impediment tested	Predicted relationship between *de novo* firms and diversifying firms	Empirical finding for predicted relationship	Description
Mitchell, 1994	Medical imaging	Age and size	Predicts *de novo* firms will dissolve (fail) at lower rates with age	Supported	For dissolution, failure rates of *de novo* fall faster with age than diversifying firms with age. For divestiture, exit rates for *de novo* rise faster with age. No difference in the effect of size.
Carroll *et al*., 1996	Automobile	Age	Convergence	Not supported	*De* novo with preproduction begin with lower hazard rates than *de alio*, but this falls more slowly as they age. Size has a larger negative effect on hazard rates for *de novo* firms than for *de alio*.
Klepper and Simons, 2000	Television	Technology regime	Divergence	Supported	Survival rates of diversifying firms are much higher than *de novo* in the last period when the industry faced disruptive technology change from color TV and semiconductors. The authors infer that diversifying firms continued to innovate in the face of new technology, while *de novo* firms did not.
Holbrook *et al*., 2000	Semiconductors	Technology regime	No prediction	NA	While *de* novo firms saw early success with technology, diversifying firms managed the industry transitions to new technology more successfully than *de novo* entrants.
Klepper, 2002a	Automobile	Age	Convergence	Not supported	Age increases the failure rate for *de novo* firms but not diversifying firms. Experienced firms generally entered earlier, and see declining hazard with time.
Klepper, 2002b	Automobile, tires, television, penicillin	Age	Convergence	Not Supported.	In auto and tires, the study does not find evidence for convergence. In television and penicillin there is evidence for *divergence* of the two types.
Bayus and Agarwal, 2007	PC industry	Technology regime	Divergence	Supported	*De novo* firms failed at higher rates than diversifying firms after the transition to a new technology regime.

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also require capabilities for renewal and reconfiguration (Karim, 2006; Karim and Mitchell, 2000; Puranam *et al*., 2009). Nevertheless, we find the growth patterns of diversifying and *de novo* firms remain practically identical when we omit subscribers added through acquisition.

In addition, our analysis hints at a flexibility advantage that *de novo* firms display. The main and simple effects of the *de novo* variable in Model 2, Table 2 provide evidence that small *de novo* firms grow at a *faster* rate than small diversifying firms, consistent with the advantages found for *de novo* firms in some studies (Agarwal *et al*., 2004; Khessina and Carroll, 2008). Also, Mitchell (1994) finds a survival advantage for small *de novo* firms as long as the firms remain small. This pattern might emerge if small *de novo* firms are able to configure their core knowledge to fit more closely with the new industry than diversifying firms, which are often constrained by commitments, investments, and attitudes inherited from their pre-entry experience. However, the nonsignificant main effect of *de novo* in Models 3 and 4, examining interactions with *tenure* and *entered in prior technological regime*, indicates that *de novo* firms are not uniformly better off than diversifying firms in the absence of impediments to growth.

Despite the widespread focus on dynamic capabilities in strategy research, this study highlights that we have not fully grasped the implications of dynamic patterns of advantage for studies of firm and industry evolution. In particular, industry studies have missed important aspects of competition because they have not examined the long-lasting and changing patterns of advantage that arise from pre-entry experience. In a sense, diversifying firms represent a hybrid in the classic 'incumbent-entrant' dichotomy that tends to cast incumbents as inertial established firms and entrants as entrepreneurial new ventures (Christensen and Rosenbloom, 1995; Cooper and Schendel, 1976; Gort and Klepper, 1982; Henderson and Clark, 1990; Tushman and Anderson, 1986; Utterback, 1994): diversifying firms are *established* firms that engage in *entrepreneurial* venturing into new markets and industries, thus, examining differences between the entrepreneurial actions of established firms and of *de novo* firms permits a better understanding of the differential benefits of such actions by firms that are at different stages of firm evolution.

The limits of the study necessarily limit the extent of our conclusions. Since we study entry into wireless telecommunications, it is possible that growth patterns will vary in other industries. A careful examination of the literature, however, finds that a number of prior studies have found evidence for divergence of firms with and without pre-entry experience and not a single study has found evidence consistent with convergence (Table 4). When weighed in the context of other overlooked evidence, then, our study represents a strong call to reconsider the widely accepted model of advantage and ultimate convergence between diversifying and *de novo* firms.

Nonetheless, firms in the wireless industry face reasonably high barriers to entry and possess valuable franchises. All the firms in our study—*de novo* and diversifying alike—managed to acquire an FCC license and install a cellular network to actually launch service. Inexperienced wireless firms, then, may more closely resemble *de novo* firms with preproduction experience (Carroll *et al*., 1996) than seat of the pants start-ups in some industries. In fact, the age contingent pattern of growth and survival we find matches very closely with the comparative pattern shown for *de novo* firms with preproduction experience and *de alio* firms in the automobile industry (Carroll *et al*., 1996). In addition, the firms possess valuable franchises that can only be operated with the license from the FCC, so all firms exited the industry through divestiture (sale) rather than dissolution. Again, our pattern of exit much more closely matches the comparative pattern of divestiture found in the medical imaging industry than it does the pattern of dissolution (Mitchell, 1994). Our understanding of dynamic advantage helps explain some anomalous findings, as well. For instance, in the medical device industry, *de novo* firms that remain small were found to have higher survival rates than diversifying firms. Since small firms that remained small did not face impediments to growth, these *de novo* firms did not suffer for their lack of dynamic capabilities.

A second important limitation is that growth is an imperfect measure of firm performance, since firms racing for market share might sacrifice profit to buy growth. In robustness analysis, however, we find the patterns of advantage over time are consistent when we analyze patterns of exit instead of growth (Table 3). Finally, the study draws conclusions about firms' relative capabilities for renewal and reconfiguration without measuring these capabilities directly. Nevertheless, we

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believe this study is a novel and valuable contribution because it explores the fine-grained pattern of renewal required for continuous growth in an evolving industry.

These limitations do suggest areas for future research. For instance, it would be useful to replicate and extend the study across other industries, to see if the pattern of growth among different firm types also depends on industry characteristics that do not vary in this study. In order to study renewal more directly, we would like to explore the pattern of executive hiring and reconfiguration among *de novo* and diversifying firms as they confront impediments to growth. Such a study could examine whether diversifying firms experience additional growth for each new executive they add, compared to *de novo* firms, or whether they simply hire more top executives in the face of impediments to growth. The first pattern would suggest superior integrative knowledge, since they integrate and leverage new executives more successfully than *de novo* firms. The second pattern would suggest that diversifying firms succeed through targeted acquisition of resources at the times their core knowledge demands it most: when they face impediments to growth. Finally, our study highlights the importance of moving beyond survival to study other outcomes, which can illustrate more fine-grained differences in capabilities, as studies have done with new product offerings (Khessina and Carroll, 2008) and reorganization (Karim and Mitchell, 2000).

Our study shows that experienced firms benefit not just from superior access to competitive resources but also from their capability for strategic renewal. For strategy and organizational theory, this suggests that a renewal advantage can be valuable to overcoming incremental challenges, such as the bureaucratic and inertial impediments to growth, as well as for dramatic transformation, such as shifting technology regimes. Thus, recent strategy research on firm evolution is more closely connected to historical interests in firm growth than we might initially suppose. In entrepreneurship, our study contributes to both corporate and new venture entrepreneurship. For corporate entrepreneurship, it highlights the advantages bestowed to firms that engage in entrepreneurial entry into new markets through the development of an important set of dynamic capabilities related to integrative knowledge and transformational experience. For new venture entrepreneurship, while *de novo* firms are widely hailed in popular discussion as more nimble and innovative than established firms, little research has supported this claim. We do find that small entrepreneurial firms grow more quickly than diversifying firms of a similar size. However, our study underscores the challenges *de novo* firms face when confronted with impediments to growth; their relative lack of experience in reconfiguring existing systems and integrating knowledge impairs their ability to grow at greater scale, after longer tenure in the industry, and after technological shocks. In this way, our study identifies specific targets for managing the challenges of growth, namely, that developing effective capabilities for renewal needs to be a priority so firms may flourish in new and evolving industries.

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