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Abstract

New industries sparked by technological change are characterized by high uncertainty. In this paper we explore how a firm's conceptualization of products in this context, as reflected by product feature choices, is influenced by prior industry affiliation. We study digital cameras introduced from 1991-2006 by firms from three prior industries. We hypothesize and find first, that prior industry experience shapes a set of shared beliefs resulting in similar and concurrent firm behavior, second, that firms notice and imitate the behaviors of firms from the same prior industry, and third, that as firms gain experience with particular features, the influence of prior industry decreases. This study extends previous research on firm entry into new domains by examining heterogeneity in firms' framing and feature-level entry choices.

Keywords: Technological change; Innovation; Industry evolution; Dominant designs, Managerial beliefs; Digital photography

Introduction

Firms entering a nascent product market face a context characterized by tremendous ambiguity and uncertainty, particularly when the new market is sparked by radical technological change. Potential customers have little or no experience with products, and their preferences are therefore unformed and unarticulated. Even basic assumptions about what the product is and how it should be used are subject to debate. Similarly, from a technological perspective, uncertainty exists about the rate of performance improvement of the new technology, how components of a technological system will interact, and whether different technological variants will work at all. Market and technological uncertainty are often compounded by competitive uncertainty as firms grapple with shifting industry boundaries and the convergence of firms from previously distinct domains. During this period of turbulence, firms experiment with alternative product configurations, functions, and technologies, with competing alternatives converging, in many cases, on what researchers have labeled a dominant design -- a standard set of technologies and interfaces as well as a shared understanding of what performance attributes are important (Utterback and Abernathy, 1975; Clark, 1985; Anderson and Tushman, 1990; Klepper, 1996).

While this basic pattern of evolution has been well-established, important gaps in our understanding remain. First, prior research on entry in the early stages of industries has treated entry as a dichotomous variable with the focus on predicting which firms enter and the timing of their entry (e.g. Klepper and Simons, 2000). We lack a more granular understanding of the many individual choices that entry comprises. In particular we know little about the forces that influence heterogeneity in entrants' interpretations of the new product market as reflected in product variants introduced, specifically at the level of product features. Firms' decisions about product features are critical as they influence consumer adoption and diffusion, and ultimately whether the new market emerges (Rindova and Petkova, 2007).

Second, while firm heterogeneity is a central tenet in strategy research, "we lack a clear conceptual model that includes an explanation of how this heterogeneity arises" (Helfat and Peteraf, 2003 p.998). The convergence of firms with diverse backgrounds in a new domain could provide an opportunity to explore the origins of heterogeneity, however existing research has emphasized only the differential capabilities associated with prior industry experience, showing that firms with related experience are more likely to enter a new industry (Silverman, 1999; Klepper and Simons, 2000; Danneels, 2002; Helfat and Lieberman, 2002). The influence of heterogeneous beliefs and assumptions that result from different prior industry experience may also be important, and this terrain remains relatively unexplored.

Finally, although a dominant design represents convergence of both technological (supply-side) and market (demand-side) characteristics (Clark, 1985), empirical studies of the emergence of dominant designs have focused primarily on the technological dimension. For example, the twenty-three papers reviewed in Murmann and Frenken's (2006) recent synthesis of the literature all assessed the emergence of a dominant design in terms of technologies, broadly defined, while the features embodied in the dominant design were rarely examined. We therefore have little understanding of the market dimension of dominant designs, including both initial variance in product features and eventual convergence on a standard set of features. Insight into this aspect is important for improving our understanding of how dominant designs emerge, and more broadly, how industry evolution unfolds.

In this paper we address these gaps by exploring how a firm's background, represented by its prior industry affiliation, influences its conceptualization of a nascent product market, as reflected by the product features it incorporates. A firm's prior industry experience is likely to matter due to a combination of capabilities, beliefs, and imitative behavior. Existing capabilities might influence product-level choices in that a firm is likely to introduce products that leverage its core strengths (Montgomery and Hariharan, 1991; Helfat and Raubitschek, 2000; Helfat and Peteraf, 2003). Given the ambiguity associated with a nascent industry, socio-cognitive processes may also play an influential role as managers attempt to make sense of confusing and often conflicting signals (Weick, 1990). Perceptions of the emerging market may thus be influenced by managerial beliefs derived from a firm's industry history (Huff, 1982; Porac, Thomas, and Baden-Fuller, 1989; Spender, 1989; Tripsas and Gavetti, 2000). Finally, during periods of high uncertainty, decision makers often imitate the behaviors of other salient firms (Haveman, 1993; Haunschild and Miner, 1997; Rao, Greve, and Davis, 2001), and the most salient firms are likely to be those competing in the same prior industry. So, how a firm interprets the emerging opportunity and its conceptualization of products in the nascent domain are likely to be influenced by its prior industry background.

Our empirical context, the emergence of the digital camera market[1], is an ideal setting for addressing these issues. First, the emergence of consumer digital cameras was characterized by high uncertainty and the entry of firms from three prior industries, photography, computing, and consumer electronics, enabling a comparison of the influence of firm background on decisions about which features a digital camera should include. Second, the digital camera market is unique in that technical capabilities were likely not a primary driver of firms' choices of which features to introduce. As we discuss in detail later, although some firms invested in developing proprietary camera technology, and we control for technical capability using patent data, a well-developed supply chain gave all firms access to the same core features, even if they had no internal capability. This allowed us to study influences of industry affiliation apart from technical capabilities on firms' choices of features. Finally, although firms' strategic decisions about market position might influence their corresponding choices of features, and there were specific market niches in the digital camera market, such as studio and professional cameras, we focus specifically on the consumer (mass) market for digital cameras. Thus, we are able to study heterogeneity in choices – and underlying beliefs – for firms participating in the same market segment. We utilize a unique longitudinal dataset that includes the entry date and features of almost every camera in the history of the U.S. consumer digital camera industry from its inception in 1991 through 2006.

We find that prior industry affiliation had a significant influence on a firm's initial framing of the nascent product market. Qualitative data indicate that digital camera product concepts and expected uses varied systematically, ranging from an analog camera substitute (photography firms), to a video system component (consumer electronics firms), to a PC peripheral (computing firms) before converging on a product concept that included elements of all three frames. Quantitative analysis of the timing of initial

[1] Consistent with research on dominant designs, we use as our unit of analysis a product market, in this case a digital camera, although digital cameras exist in the broader context of digital imaging.

product feature introduction further supports these systematic differences. Our results suggest that firms from the same prior industry shared similar beliefs about what consumers would value as reflected in their concurrent introduction of features -- firms were significantly more likely to introduce a feature, such as optical zoom, to the extent that other firms from the same prior industry entered with the feature in the same year, whereas concurrent entry by firms from different prior industries had no influence. Firms were also likely to imitate the behavior of firms from the same prior industry, as opposed to that of firms from different prior industries in introducing some, but not all features. Finally, we find that as a firm's experience with a particular feature increased, the influence of prior industry decreased.

Technological change, market uncertainty, and patterns of industry emergence

Studies of industry evolution following major changes in technology[2] have documented a consistent pattern of progress, falling into three prototypical stages: an era of ferment, convergence on a dominant design, and an era of incremental change (Utterback and Abernathy, 1975; Anderson and Tushman, 1990; Klepper and Graddy, 1990).[3] High levels of experimentation by both firms and customers dominate an era of ferment. For instance, early automobiles utilized a variety of mechanisms for steering, ranging from a joy-stick-like tiller to steering wheels; the internal combustion engine competed with electric and steam engines, and some vehicles had three wheels, not four (Abernathy, 1978; Basalla, 1988). As Rao (1994 p.33) put it, "The only point of agreement about the automobile was that it could not be powered by animals." In addition to technical variation, fundamental beliefs about what the product is and what functions it should perform vary. A customer's choice in the era of ferment "involves both the formation of concepts with which to understand the product, and the development of criteria to be used in evaluation," (Clark, 1985 p. 244). For instance, early in the automobile industry's history, Americans conceived of an automobile as a "horseless carriage" whereas

[2] Sometimes a radical technology from the perspective of one industry may actually be the application of technology that has been incrementally developing over time in a different context (Levinthal, 1998; Tripsas, 2008).
[3] These stages are essentially the same as what Utterback & Abernathy (1975) label Fluid, Transitional and Specific stages, and what Klepper & Graddy (1990) label Growth, Shakeout, and Stabilization stages.

"the French thought in terms of a road locomotive," (Langlois and Robertson, 1989 p.366). These different perspectives were reflected in the product design, features, and technologies employed. Similarly, early in the evolution of cochlear implants, alternative visions of what the product should be resulted in completely different performance metrics being valued (Garud and Rappa, 1994).

In some cases the industry coalesces around a dominant design, which reflects both technological convergence -- consensus about a set of standard technologies, modules, and interfaces (Utterback and Abernathy, 1975; Anderson and Tushman, 1990; Utterback and Suarez, 1993), as well as cognitive convergence – a shared understanding of what the product is, how it will be used, and which core attributes will have value (Kaplan and Tripsas, 2008). The process by which a dominant design emerges is a complex combination of economic, social, political, and cognitive dynamics, and scholars have demonstrated that the technologically superior alternative does not necessarily win (Cusumano, Mylonadis, and Rosenbloom, 1992; Tushman and Rosenkopf, 1992; Utterback, 1994; Suarez, 2004). Although the dominant design represents the core elements of a new product class, its emergence does not imply that products can no longer be differentiated. In fact, competition after the emergence of a dominant design is often based on quality, reliability, brand, and new peripheral features (Utterback, 1994).

While this pattern of high variation and eventual convergence on a dominant design has been documented in a range of industries, our understanding of the sources of initial heterogeneity is limited. Other than the general argument that *de novo* firms are an important source of entry and innovative technology in many industries (Cooper and Schendel, 1976; Tushman and Anderson, 1986; Christensen and Bower, 1996; Martin and Mitchell, 1998), we lack a good sense of whether and why different firms might introduce systematically different product variants in the same nascent market. Diversifying entrants play an important role in many new industries, but the focus of most research has been on whether firms enter, when they enter, and whether they survive – not on the variation in product artifacts they introduce (e.g. Mitchell, 1989; Mitchell, 1991; Carroll *et al.*, 1996; Dowell and Swaminathan, 2006). In addition, research has assumed that differences stemming from prior industry affiliation are a result of variation in resources and capabilities. For instance, radio producers, which had capabilities that were close to those needed to produce televisions, were more likely to enter the TV receiver industry, to enter early, and to survive (Klepper and Simons, 2000). Similarly, of diversifying entrants in the automobile industry, bicycle and carriage manufacturers were more likely to survive than engine manufacturers (Carroll *et al.*, 1996). Much less consideration has been given to the possibility that prior industry affiliation also reflects shared beliefs and a common set of peers that are noticed and potentially imitated. Given that technological change is increasingly resulting in the competitive convergence of firms from previously distinct industries (Brusoni, Jacobides, and Prencipe, 2009) a deeper understanding of the influence of prior industry affiliation – one that takes into account both capabilities and cognition -- is needed.

Moreover, empirical studies of the evolution of new product markets have focused on the technological, not market dimension of a dominant design. For example, in Christensen, Suarez, and Utterback's (1998) study of the rigid disk drive industry, they identify and track four technologies that make up the eventual dominant design: the Winchester architecture, the under-spindle pancake motor, rotary voice-coil actuator motors, and embedded intelligence interface electronics. The demand-side product features that might be associated with different assumptions about customer preferences and use are not considered in the dominant design measure. Similarly, in Baum, Korn and Kotha's (1995) study of the facsimile transmission equipment industry, the Consultative Committee on International Telephone and Telegraph (CCITT) technical standards for facsimile transmission were used to define the dominant design. By examining the market dimension of a dominant design, this paper fills an important gap in our understanding of how different actors arrive at a common interpretation of what a new product category represents.

The influence of prior industry affiliation on framing of a nascent product market

We next develop a set of hypotheses about how a firm's prior industry affiliation influences the way managers frame a new product market, based on a firm's initial introduction of particular product features and its ongoing commitment to those features. In doing so, we explicitly distinguish between the influence of shared industry beliefs and the influence of imitative behavior, both constructs that can result from common industry affiliation.

Existing research suggests that similar prior experiences and ongoing interactions give rise to a shared set of beliefs for members of the same industry. Huff (1982 p.125) proposed the theoretical argument that managers of organizations in the same industry develop “shared or interlocking metaphors or worldviews” such as common beliefs about customer preferences, the role of regulation, and future levels of industry demand. In subsequent research, scholars have provided strong empirical support for the notion of industry-level frames. Spender (1989 p.188) identified sets of “industry recipes,” noting that “executives adopt a way of looking at situations that are widely shared within their industry.” Similarly, Porac, Thomas, and Baden-Fuller (1989 p.400) articulated a set of shared causal beliefs held by Scottish knitwear manufacturers concerning customers, suppliers, retail, and competition, noting that “over time the mental models of competing strategists become similar thereby creating ‘group level’ beliefs about the marketplace.” Extending this work, Porac, et al (1995) developed the concept of an “industry model” which represents collective recognition on the part of producers about what fundamental attributes should be used to categorize competitors and which firms belong in which categories.

Industry-level beliefs are important because they influence decision-making and action (Levitt and March, 1988). In the photolithography industry, firms developed shared, but mistaken, assumptions about the direction of change in the underlying technology, and these resulted in erroneous projections about performance limits by firms in the industry (Henderson, 1995). Bogner and Barr (2000 p.221) proposed that in hypercompetitive industries, constant, rapid change became the norm, and this “common cognitive framework” of industry members in turn perpetuated the hypercompetitive environment. The manner in which firms evaluate acquisition targets has also been shown to vary depending on industry background (Hitt and Tyler, 1991).

Commonly held perceptions, expectations, and assumptions become particularly salient when firms enter a highly uncertain emerging industry that incorporates novel technologies with novel uses. In this context, managers lack concrete data about what consumers value and therefore must make assumptions about how customers will use the product and what features will have merit. The process by which firms with the same prior industry affiliation may apply common assumptions is twofold. First, managers may "reason by analogy," transferring beliefs about prior situations to novel situations that they perceive to be similar (Gavetti, Levinthal, and Rivkin, 2005). Past experience with similar customers may create common expectations about what customers will value in a new domain. Second, ongoing interaction among firms from the same prior industry may create a forum for direct sharing of information about the emerging industry since firms are more likely to pay attention to and interact with familiar peers (Ocasio, 1997). A variety of venues such as industry consortia, standards committees, trade associations, and industry conferences have been shown to facilitate relationships and sharing of information (Lampel, 2001; Rosenkopf, Metiu, and George, 2001). In aggregate, these mechanisms may reinforce common expectations among firms from the same prior industry.

Thus, firms from the same prior industry are likely to make similar assessments of which product features customers will value and are therefore likely to first introduce a given feature at a similar time. Put differently, we propose that concurrent introduction of a feature is an indication of shared beliefs about the value of that particular feature.

> H1: In the nascent stage of an industry, the greater the number of other firms from the same prior industry that introduce a produce feature during a period (as opposed to firms from a different prior industry) the greater the likelihood a firm will introduce the product feature in that period.

Neoinstitutional theory holds that firms in the same industry, subject to similar institutional forces, are also likely to imitate each other (DiMaggio and Powell, 1983). Researchers have documented that firms facing similar institutional environments tend to adopt similar structures and practices, including for example, civil service reforms (Tolbert and Zucker, 1983), multidivisional structures (Fligstein, 1985), or naming conventions (Glynn and Abzug, 2002). Moreover, firms are more likely to imitate the practices and behaviors of similar, comparable firms than to imitate firms they categorize as distant (Haveman, 1993; Haunschild and Miner, 1997; Baum, Li, and Usher, 2000). The tendency for mimetic isomorphism or imitation is heightened under conditions of high uncertainty such as entry into new markets (Haveman, 1993; Greve, 1996; Korn and Baum, 1999). Imitation is likely a factor not only in decisions about whether to enter new, emerging domains, but also in choices about how firms enter, i.e. how they conceptualize the new product and which features they include. In the highly uncertain setting of an era of ferment, therefore, firms are likely to imitate the features that have already been introduced by other firms from the same industry background.

> H2: In the nascent stage of an industry, the greater the previous introductions of a given product feature by other firms from the same prior industry, the greater the likelihood a firm will imitate them and enter with that feature (as opposed to imitate firms from a different prior industry).

Thus H1 suggests that due to shared beliefs, firms with the same background are likely to behave in similar ways, while H2 suggests that even absent shared beliefs, firms are likely to imitate other firms from the same prior industry, first observing the product attributes introduced, and then engaging in the same behavior in a subsequent period.

Our discussion so far concerns the choices that firms make in their initial introductions of product features, when they have limited data and must rely on prior beliefs or observations of other salient firms for making decisions. But these influences may dissipate over time as firms gain knowledge based on their own experience. A wide body of organizational learning research has shown that as they gain experience in a product market, firms tend to engage in local search, introducing new product variants that are similar to previous models (Martin and Mitchell, 1998; Katila, 2002; Katila and Ahuja, 2002). And in a study of South Korean firms in China, Guillen (2002) found that while firms imitated other firms from the same home-country industry in the their rate of foreign expansion, this effect decreased once a firm had made its first foreign entry. Prior research has also shown that although decision makers may initially imitate other firms in situations of high uncertainty, updated information based on experience can lead to abandoning a particular course of action (Fiske and Taylor, 1991; Rao *et al.*, 2001). Similarly, in our context, once a firm has introduced products with particular features, it gains knowledge about the level of demand and has access to information from customers to better understand usage behavior. Thus, a firm's own experience with features is likely to play a heightened role in subsequent decisions about whether to continue to incorporate those features in its products, and the influence of prior industry beliefs and peers is likely to decrease.

> H3: In the nascent stage of an industry, the more experience a firm has with a particular product feature, the lower the influence of other firms from the same prior industry on the firm's commitment to that product feature.

DATA AND RESEARCH SETTING

Overview of the digital camera industry

Digital camera technology utilizes semiconductor chips such as CCDs (charge-coupled devices) to capture and convert light images to binary data, replacing the role of silver halide film in analog cameras. Beyond image capture, digital technology offers the benefits of transfer, manipulation, and storage of digital images. The first consumer digital camera in the US, a non-color grayscale, 90,240 pixel camera that could store 32 images in internal memory, was available in 1991, and by 2003 sales of digital cameras exceeded those of analog cameras.

The emergence of consumer digital cameras provides an ideal context in which to study the differential effects of prior industry background since the majority of the 83 entrants in the US from 1991 to 2006 came from three prior industries: photography (25 firms), consumer electronics (19 firms), and computing (25 firms). There were only 9 de novo start-ups and 5 diversifying entrants from unrelated industries (e.g. Mattel and Disney). Firms were classified as follows: if a firm made analog cameras or film, it was coded as photography, even if it also made other products (e.g. Canon). Similarly, if a firm produced camcorders, TVs, stereos, or MP3 players, it was coded as consumer electronics (e.g. Sony). Firms that made PCs, peripherals, software and/or components were coded as computing. Table 1 provides a list of entrants' prior industry classifications. There is clearly variation within our broad industry groupings, but our approach is conservative in that this variation would tend to decrease the likelihood of finding a prior industry effect. While selection bias is an issue in some studies of entry, in this case every major analog camera, photographic film, and consumer electronics firm entered the market, limiting possible selection issues to computing firms that could have entered, but did not (e.g. Dell, Microsoft). However the range of computing firms that did enter is reasonably broad, and based on a comparison, we have no reason to believe that the computing firms that did not enter differ systematically from those that did.

The digital camera market is also ideal for studying the role of prior industry affiliation in shaping perceptions and interpretations in that we can largely separate decisions about introducing product features from the capabilities required to implement those features. While a subset of firms invested in developing technical capability that allowed them to design and manufacture digital cameras, firms with no technical expertise could also introduce digital cameras by utilizing a well-developed supply chain that had the expertise required to develop the features that were eventually standard. For instance, Ritz Camera, a photography retailer with no product development expertise, introduced a consumer digital camera in 1995. “Digital camera components are readily available, products can be developed fairly quickly and production (part assembly) can be done relatively easily,” explained a financial analyst who covered Fuji Photo Film (HSBC Chemicals, 2000, p.14). In addition, camera manufacturers could choose from multiple suppliers for each feature. A Morgan Stanley analyst report identified 9 zoom lens suppliers, 10 LCD screen suppliers, and 16 image sensor chip suppliers (the ability to introduce higher megapixels was driven by sensor chips) (Morgan Stanley, 2002). Even component developers that participated in the digital camera industry generally supplied their components to others. Kodak, an early leader in high end CCD sensor technology created a separate Image Sensor Solutions division to serve as a merchant market supplier of both CCD and CMOS sensors, and Kodak’s consumer digital cameras mostly incorporated sensors from other suppliers.

In addition to component suppliers providing access to features, a vibrant OEM/ODM industry developed early on providing design, integration, and manufacturing services to firms wishing to introduce a digital camera. Firms could choose from a menu of features available in digital camera reference designs developed by OEM/ODMs. Japanese firms such as Chinon were producing cameras for others as early as 1993. Taiwanese firms entered the OEM/ODM industry in 1997, and by 1999 it was estimated that 10% of digital cameras worldwide were produced by Taiwanese ODMs/OEMs (Taiwan Economic News. 1999) rising to 20% in 2000 (Taiwan Economic News. 2000).

Some firms that entered the digital camera market did invest in developing technological capability, but these firms were the minority. Of the 83 firms that entered the digital camera market, 31firms had no patents in classes related to digital cameras from 1983-2003, 20 firms had fewer than 50 patents, and a core set of 20 firms had over 1000 patents (see Table 2 for a list of patent classes related to digital cameras.) One might expect that firms would be more likely to introduce features that leverage their technical capabilities, and we test for this effect in our quantitative analysis, however, qualitative data indicate that even among these firms, the timing of a new feature was not driven by this technological capability. For instance, although Kodak had one of the highest patenting rates, the head of the consumer digital imaging unit from 1997-2005 explained to us in an interview that, "Kodak's decisions to offer consumer digital cameras with features such as optical zoom, movie clips, or higher resolution were driven by our perception of what consumers were willing to pay for, not by our technical capability to develop or manufacture the underlying components."

By taking advantage of the characteristics of this setting, as well as directly controlling for technological capabilities in our models, we are therefore able to better untangle firms' framing and conceptualizations of the appropriate features for a digital camera from considerations of their technical capabilities in our tests of the influence of prior industry.

Sources and Data

Our dataset includes comprehensive longitudinal data covering the history of consumer digital imaging in the US from 1991 through 2006. It covers every firm to introduce a branded digital camera in the US (private label cameras are excluded), and every digital camera introduced by these firms from 1991 through 2006. Since we focus on the mass market for digital cameras, we excluded from our analysis types of digital cameras that we determined were distinct product markets that would experience their own separate processes of variation and convergence on a dominant design: studio/professional cameras, webcams, single lens reflex cameras (SLRs), and mobile phone cameras.[4]

Quantitative data were hand collected from a broad range of primary and secondary industry sources including company and industry association archives. Detailed information on digital camera specifications came from a combination of trade publications (e.g. the Future Image Report, PC Photo and Popular Photography), research reports (e.g. International Data Corporation and Forrester), archived product specifications from company websites, archives from photography industry websites (primarily dpreview.com, imaging-resource.com, and dcviews.com), and press coverage of the industry throughout the time period. The entry date and specifications for each camera were cross-checked and confirmed by at least two of these sources. In all, our dataset includes 1629 digital cameras introduced by 83 firms during this period. Quantitative data were supplemented by extensive field work, including attendance at multiple industry conferences such as the annual Photo Marketing Association conference, as well as in-person interviews with over 50 individuals involved in the industry including employees of photography, consumer electronics, and computing firms, as well as outside industry experts such as the editors of the Future Image Report.

Emergence of a Dominant Design in Consumer Digital Cameras

Consistent with the pattern found in prior research on technological change (e.g. Utterback, 1994; Anderson & Tushman, 1990), the advent of digital photography triggered rapid innovation, uncertainty, and competition among product designs, features, and technical variants, with eventual convergence on a standard camera – a dominant design. To trace the emergence of a dominant design for digital cameras, we identified and tracked adoption of a set of key camera features. This approach is unique in that it focuses on the market dimension in contrast to prior empirical measures, which have

[4] The earliest digital cameras in the mid-1980's were studio and professional cameras that resembled scanners, captured up to 16 megapixels, were priced in the $16,000 to $20,000 range, and were produced and sold primarily by graphic arts firms that did not enter consumer digital photography. Webcams, sometimes called "eyeball' cameras, were tethered to a PC and provided video-conferencing capability over the Internet. Consumer-oriented digital SLRs, while sharing some attributes with consumer-oriented digital cameras, did not really emerge as a category until 2002 at which point non-SLR cameras were already beginning to coalesce on a dominant design. Similarly, the first mobile phone cameras were not introduced in the US until 2002, largely after our period of study.

focused almost exclusively on the technological dimension (e.g. Anderson and Tushman, 1990; Christensen, Suarez, and Utterback, 1998). For instance, we examined whether a firm introduced higher levels of camera resolution, but did not examine what underlying sensor technology (CCD or CMOS) firms used to deliver that resolution. Similarly, we examined whether a firm introduced a removable memory feature on a camera, but not what technical variant of removable memory was included (e.g. Compact Flash versus Microdrive). As suggested by Suarez (2004) we considered a dominant design to have emerged only when over 50% of new models had all of the elements that were included in the design, and that percentage was continuing to increase.

The features we tracked were: LCD Display, optical zoom lens, digital zoom software, movie clips, resolution, removable storage, and dual webcam capability. We chose these features because they were included systematically in descriptions of digital cameras in both industry trade publications such as the Future Image Report, and mass market publications such as Consumer Reports. Our goal was to capture features that had uncertainty associated with them, so we excluded features such as 'color,' since it seemed color would be an obvious choice for firms. We also excluded features that diffused rapidly such as 'flash,' since they did not provide enough variation in the timing of firm introduction to allow for analysis. With the exception of dual webcam capability, all features became part of the dominant design.

Whether to include most camera features was a binary choice for a firm – either the camera had the feature or didn't. Image resolution, however, was what Rosenkopf and Tushman (1994) call a dimension of merit. All digital cameras have resolution, so the choice firms faced was whether to incorporate higher levels of resolution. We therefore sorted cameras into resolution categories, enabling us to also analyze introduction of higher resolution cameras as a binary choice. The first category included cameras with VGA resolution (the 307,200 pixels of a computer screen) or lower. The next category comprised cameras with higher than VGA resolution, up to and including 1 megapixel cameras. For higher resolutions we followed the norm in the industry and categorized models as 2 megapixel (2 million through 2.9 million pixels), 3 megapixel, and so on.

Table 3 describes each of these features in more detail and summarizes when they were first introduced and how quickly they were adopted. Figure 1 shows the percentage of new cameras introduced each year that incorporated each feature. Wide variance in features is evident in the early years. For instance, in 1997, LCD displays were offered in 63% of new cameras, optical zoom in 17%, digital zoom in 5%, movie clips in 12%, over VGA resolution in 28%, removable storage in 70%, and dual webcam capability in 10%. Uncertainty is also evident in that the majority of features experienced both increases and decreases in penetration over time. By 2006, however, all features, except for dual webcam capability, were present in almost all new cameras (only 13% of new models had dual webcam capability.) While individual features were introduced earlier, the first camera to incorporate all elements of the dominant design was introduced in 1999, and it wasn't until 2004 that the dominant design was solidified, with over 50% of new models incorporating all elements. We therefore define the nascent stage of the market as extending from 1991 through 2003 and exclude subsequent years from our quantitative analysis.

The role of prior industry affiliation on framing: descriptive analysis

Before turning to a quantitative analysis of the introduction of features, we first examine descriptive data on the initial introduction and subsequent diffusion of features to identify preliminary patterns that distinguish the influence of prior industry. While in retrospect the elements of the dominant design may seem obvious, in the moment there was high uncertainty about how products would be used and what features would be valued (Munir, 2005; Srinivasan, Haunschild, and Grewal, 2007). For example, in 1993, a VP from Leaf Systems noted, "the thing about scanning is that there already was a perception in the marketplace of what a scanner was…Electronic photography is quite different." (Future Image Report, 1993). Table 4 compares the initial introduction and adoption rates of features by firms from each prior industry. These descriptive data seem to reflect different interpretations of what a digital camera represented depending upon what industry a firm originated in.

Photography firms appear to have conceived of a digital camera as a device that would be used in a manner similar to an analog point and shoot camera, including the printing of images. Indicative of this mindset, these firms led the introduction of high resolution, optical zoom, and removable storage features, were later in their introduction of movie clips, and introduced few models with dual webcam capability. Although the resolution of digital cameras (measured in pixels) ultimately emerged as an important product feature, early on the perceived value of exceeding the VGA resolution of a computer screen depended upon whether members of a firm believed that consumers would primarily display images on a TV or computer, or whether they would also want to print pictures (in which case high resolution would be valued). The first camera to offer higher than VGA resolution was introduced by Kodak in 1995 and by 1996 over half of the photography firm models had high resolution (compared with 1998 for consumer electronics and computing firm models). Fuji was the first to introduce an optical zoom model in 1992, and by 1998 over half of the photography firm models had optical zoom, a feature that was common in analog film point and shoot cameras. In contrast it wasn't until 2004 that half of computer firm models had optical zoom. Removable storage enabled users to remove a memory card and take it to either a digital minilab or retail kiosk for prints, similar to the behavior of consumers using analog film cameras. This feature was also first introduced by Fuji in 1992 and by 1995 over half of the photography firm models had removable storage (compared to 1997 for consumer electronics and computing firms).

In contrast, photography firms were later to introduce the movie clips feature, which allowed the user to capture and store short video clips. As one photography industry executive told us, "Photography firms figured that if people wanted to take movies, they'd use a camcorder. They didn't need that feature in a camera." It wasn't until 2001 that half of the photography firm models had the movie clip feature, compared to 1999 for consumer electronic firm models. Similarly, the webcam feature was also not perceived as valuable by photography firms, and the penetration of that feature peaked at 17% of camera models for photography firms.

Consumer electronics firms appear to have conceived of a digital camera as a video system component, and consistent with this vision, they led the introduction of LCD displays and movie clip features and were slower introducing high resolution and removable storage. LCD displays were already a standard feature of camcorders, and on digital cameras, they allowed the user to preview and selectively delete images taken with the camera. LCD displays were first introduced in 1995 in the QV10 camera introduced by Casio. ”Because it was not a camera or film company, Casio was unencumbered by traditional concepts of what a ‘digital camera’ ought to be,” noted an industry analyst (Future Image Report, 1997). In fact, the original concept for the QV10 was not “a digital camera with an LCD screen, it was to be an LCD TV with a built-in digital camera.” (Aoshima and Fukushima, 1998 p.369). The TV tuner feature was eventually taken out as the product concept evolved. By 1996 half of the consumer electronics industry models had LCD displays (compared with 1997 and 1998 for photography and computing firm models). Consumer electronics firms also led the adoption of the movie clips feature, reflective of the expectation that consumers view a digital camera as similar to a camcorder. Half of their models incorporated the feature by 1999 (compared with 2001 for photography and computing firms.) The expectation that consumers would not print is reflected in the later adoption of the high resolution and removable storage features. One of the developers of Casio’s first digital camera stated, “It started with a more or less simple idea to feed the image to a TV. In this respect, image quality similar to a VHS frame [76,200 pixels] was quite acceptable.” (Aoshima and Fukushima, 1998 p.375). Similarly in 1997 by an industry analyst noted, “It never occurred to Sony that images from a digital camera would be displayed predominantly on a computer as opposed to a TV.” (Future Image Report, 1997).

Computer industry firms appear to have viewed a digital camera as a PC peripheral, with the expectation that consumers would either leave their camera tethered to a PC, or after taking pictures, upload them to a PC for transmission or display. Intel brochures from 1997 were quite explicit, promoting their product as a “PC camera.” Similarly, the company press release announcing the Logitech Fotoman in 1991 described it as, “a portable, ergonomically designed digital camera for IBM PCs.” (Business Wire, 1991). This perception was reflected in the relatively late adoption of high resolution, removable storage, and optical zoom as well as the relatively early adoption of digital zoom and webcam capability. Digital zoom involves software manipulation of the image to create a 'close-up' which is a cropped version of the original image. Over half of computing firm models had the feature in 1998 (compared with 1999 for photography firms). The dual webcam feature enabled a camera to serve as a webcam and do real time streaming video through a personal computer over the Internet in addition to functioning as a stand-alone camera. Although almost half of the models from computer firms had the feature in 2001, for photography and consumer electronics firms the percentage of models with the feature peaked at about 20%.

The role of prior industry affiliation on framing: quantitative analysis

The descriptive data suggest that prior industry affiliation was an important influence on how firms conceptualized a digital camera. We next use quantitative data on the timing of camera feature introductions to more formally test our hypotheses.

Measures

Dependent Variables:

Initial introduction of features: For testing Hypotheses 1 and 2, we used a binary dependent variable that has a value of 1 in the first year that a firm introduces a model with a given product feature (e.g. LCD display). The firm is at risk of introducing a feature starting the year after a digital camera with that product feature was first introduced into the industry and ending once the firm introduces a model, the firm exits the digital camera industry, or the time period under consideration (through 2003) ends. Since the choice of features for a firm's initial digital camera reflects the firm's framing of the opportunity in the context of high uncertainty, we included the first model introduced by a firm in the analysis.

Ongoing commitment to features: To test hypothesis 3, we used two different dependent variables. For all features other than resolution, we measured a firm's ongoing commitment to a feature as the *number of digital cameras introduced by firm i in year t* that have a particular feature. The data for these analyses begin in the year following the firm's initial year of entry into the feature. For the analyses of the digital camera resolution feature, we examined the timing of a firm's entry into each subsequent megapixel generation from 2 megapixels to 6 megapixels, since an ongoing commitment to high resolution is indicated by a firm continuing to introduce increasingly higher resolution cameras, (as opposed to more camera products with greater than VGA up to 1 megapixel resolution).

Independent Variables:

To test H1, that firms from the same prior industry held shared beliefs, we compared the effect of *Concurrent entry by other firms from* ***same*** *prior industry*, and *Concurrent entry by firms from a* ***different*** *prior industry*, counts of the number of other firms with the same and with different prior industry affiliations that introduced a particular feature in year t. If firms from the same prior industry have similar beliefs about what features to incorporate in a camera, then they should be more likely to introduce a feature at the same time, as opposed to at the same time as firms from a different industry.

To test H2, that firms are likely to notice and imitate firms from the same prior industry more than firms from a different prior industry, we compared the effect of *Cumulative previous entry by firms from* ***same*** *prior industry* and *Cumulative previous entry by firms from a* ***different*** *prior industry*, counts of the cumulative number of other firms with the same and with different prior industry affiliation that have introduced a particular feature as of year t-1. For example, for photography firms such as Nikon or Kodak, we measured the cumulative number of other photography firms that had introduced a camera with a feature (e.g. optical zoom) in prior years and the cumulative number of non-photography firms that had introduced the feature in prior years.

For testing hypothesis 3, that firm experience with a feature moderates the relationship between prior industry affiliation and a firm's ongoing commitment to a feature, we examined the interaction between the market presence of firms from the same prior industry in the feature and a firm's own experience with the feature. Both main effects were mean centered, with mean-centered values used to compute the interaction. We measured *Firms from same prior industry present in feature* as a count of the number of firms from the same prior industry that are currently in the market with a camera that has the feature. We measured *Firm experience in feature* using the cumulative number of models with the feature that the firm has introduced as of year t-1. If prior industry influence diminishes with experience, the interaction between these two measures should be negative. Finally, we also controlled for *Firms from **different** prior industry present in feature*, a count of the number of firms from a different prior industry that are currently in the market with a camera that has the feature.

Control Variables:

We controlled for several other factors that might affect the introduction of digital camera features. A firm's technological knowledge and related capabilities may affect its introduction of particular features, so we controlled for *technical capability* using a cumulative count of granted digital camera patents, coded by application date, starting in 1983. We obtained patent data from the NBER patent database. Since the technologies used in a digital camera are categorized in multiple patent classes, we generated a comprehensive list of classes by searching the USPTO database for patent titles and abstracts related to each digital camera feature and recording the classes. A list of the patent classes included for all features is shown in Table 2. We used the log of patent counts (adding one before logging) in our models.

A firm's commitment to and participation in the broader digital imaging industry may influence introduction of features, so we controlled for the *breadth of a firm's digital imaging offerings*, a time-varying measure calculated as the number of digital imaging product categories in which a firm participates in a given year, including photo printers, photo finishing/sharing websites, photo editing software, desktop scanners, and removable memory cards. Participation in closely related markets may also influence feature introduction, so we included controls for whether a *firm is present in the webcam, camcorder, and digital SLR markets in year t*. Each of these variables was set to one if the firm was in that market in the current year. A webcam was defined as a device that is tethered to a PC and, with appropriate PC software enables live video/audio streaming – videoconferencing. Most webcams can also capture still images, which are stored on the PC. A camcorder was defined as either an analog or a digital device that's primary function is to capture video. A digital SLR camera was defined as a device that has exchangeable lenses and through the lens viewing.

Firms that have more digital camera models available in the consumer market may have a higher likelihood of introducing a feature simply because they offer more cameras. We therefore controlled for *firm models on the market in year t* using a count of the number of digital cameras that the firm has on the market in the year. Since larger firms may have the resources to experiment in a broader range, we controlled for *Firm size*, measured as sales at the corporate level. The firm size distribution is skewed, so we took the log of sales. For public firms, data was obtained from Compustat. For private firms, data came from a combination of Wards, Dun & Bradstreet, OneSource, and trade press articles in which the firm disclosed sales figures. Missing years for private firms were interpolated based on the years for which data was available. Nine firms had no publicly available sales data, but based on press releases and information about number of employees, these firms were all classified as having sales of less than $10M. The *firm size* variable was constructed in $10M increments, so for firms with sales less than $10M, firm size=1, $10-$20M, firm size=2, $20-$30M, firm size=3 and so forth. We controlled for whether a firm is *Public* with a dummy variable that equals one if it is publicly traded in the current year. Finally, *Non-US* is a dummy variable set to one if a firm has its headquarters outside of the U.S.

Models

To test hypotheses 1 and 2 concerning the influence of prior industry background on the initial introduction of product features, we used event history analysis, specifically a Cox Proportional Hazard model. Event history models analyze the length of time it takes for a specific event to occur. In our case the event is a firm's initial entry with a particular camera feature. The hazard function can be interpreted as the likelihood that a firm introduces a particular feature at time *t*. A Cox model is advantageous because it does not make assumptions about the particular shape of the underlying hazard function. This method is appropriate for our analysis, since there is no theory to suggest any specific underlying functional form for the hazard of a firm introducing a new product feature during the advent of a new industry. In a Cox model, the hazard rate is a function of the unspecified baseline rate and the exponential of a vector of covariates, as represented by the following equation:

$$r(t)=h(t)\exp(\beta X) \tag{1}$$

Where h(t) is the baseline hazard rate and βX represents the influence of the vector of covariates. We split the data into annual spells to allow for time-varying covariates and used robust standard errors clustered by firm to account for interdependence between observations from the same firm. We ran separate models for each feature since, while we hypothesize that the effect of the variables of interest will be in the same direction, we have no reason to believe that the magnitude of the coefficients will be the same for all features. We ran the models using *stcox* in STATA.

To test hypothesis 3, assessing whether firm experience with a feature diminishes the influence of prior industry, we used a negative binomial specification. Our dependent variable for this analysis is a count of camera models with a feature introduced by firm *i* in year *t*. Models with count measures as dependent variables may be misspecified if estimated with Ordinary Least Squares (OLS) regression (King, 1988) and are more appropriately modeled with a Poisson specification. However, Poisson models rely on the strong assumption of a Poisson distribution, which requires that the mean and variance be equal. Overdispersion, when the variance is not equal to the mean, violates the Poisson assumption (Cameron and Trivedi, 1990). Overdispersion can occur if the probability of later events exceeds that of earlier events, suggesting contagion or diffusion. This situation is particularly likely in our setting with the growth in adoption of specific digital camera product attributes and technologies over time. To correct for overdispersion, we employed a negative binomial model, which relaxes the assumption of equal mean and variance and includes an error term to capture overdispersion.

We used a panel data negative binomial specification with random effects (e.g. Guo, 1996), (the *xtnbreg* command with the random effects option in STATA). A random effects specification considers both between-firm as well as within-firm variation, thus accounting for the non-independence of multiple observations for each firm and providing robust standard errors. Results were similar for models with and without random effects. The panel negative binomial models are represented by the following equation, modeled as the logarithm of the mean count λ_{it}:

$$\log \lambda_{it} = X_{it} \beta + \sigma\varepsilon_i + \mu_i \qquad (2)$$

alternatively, $Pr (y_{it} = r) = (\lambda^r \varepsilon^\lambda)/r!$; where y_{it} is the observed count and r is an integer; X is a vector of characteristics of firm *i* at time *t*, σ is a correction for overdispersion, and μ_i is a time-invariant firm i effect, which in our model is treated as a random effect.

For testing hypothesis 3 in the context of camera resolution, we used a multiple event hazard model in which we examined a firm's initial entry into subsequent megapixel generations (using the *stcox* procedure in STATA). Following Wei, Lin, and Weissfeld (1989), we combined all megapixel generations (2MP-6MP) into one model, such that a firm is at risk of entering each MP generation and can have multiple entry events – one for each generation. We stratified the data on MP generation, thus allowing each generation to have its own baseline hazard function. We also clustered on firm and used robust standard errors to control for the lack of independence of observations.

RESULTS

Table 5 shows the descriptive statistics broken out by each feature analyzed.

--------------------------------------- Tables 5 and 6 about here ---------------------------------------

Table 6 displays the results of the hazard rate analysis to test hypotheses 1 and 2, examining how a firm's initial introduction of digital camera features in the market was influenced by the firm's industry background.[5] In support of H1, *Concurrent entry by other firms from the* ***same*** *prior industry* was significantly associated with the likelihood of entry for all features except higher than VGA resolution. For each additional firm from the same prior industry that introduced a product with a particular feature during the year, the likelihood of a firm introducing that feature increased, ranging from a 22% increase

[5] We ran separate models to test H1 and H2 and the results were same as when we ran one model with both independent variables of interest, so we have included only the models with both independent variables in Table 4.

for an LCD display (model 1) to an 87% increase for the dual webcam feature (model 7). In contrast, *Concurrent entry by firms from a* ***different*** *prior industry* did not have a significant effect on the introduction of any features, and its coefficient was significantly different from that of *Concurrent entry by other firms from the same prior industry* except for resolution. For the resolution feature (model 4), the lack of significance may indicate that uncertainty surrounding the desirability of greater resolution was not actually high. If the notion that "more is better" was widely shared throughout the industry, then the introduction of higher resolution cameras would not be influenced more by prior industry peers. Overall, a firm was more likely to introduce a feature at a given time if other firms from the same prior industry were also introducing it (as opposed to firms from a different prior industry), reflecting stronger shared beliefs among firms with similar backgrounds than among all firms entering the new market.

Hypothesis 2, that firms will imitate other firms from the same prior industry was supported for three features: LCD displays, digital zoom, and high resolution. As seen in models 1, 3, and 4 of Table 6, *Cumulative previous entry by firms from the same prior industry* had a positive and significant coefficient whereas the coefficient on *Cumulative previous entry by firms from a different industry* was not significant. The strongest impact was for the digital zoom feature; for each additional firm from the same prior industry that had previously introduced a digital zoom camera, a firm was 17% more likely to introduce a camera with the feature. For other features, however, imitation of firms from the same prior industry was not evident, and for the movie clips feature, it appears that firms imitated firms from other prior industries. While imitation has proven to be a powerful force in other settings, at the level of introducing product features, the results are mixed. It appears in this setting that shared beliefs from prior industry affiliation, reflected by concurrent entry, had a stronger and more consistent influence than mimetic behavior.

Technical capability, which we controlled for with a cumulative count of digital imaging patents, did not have a significant effect on the timing of firm entry into particular features, and including these controls did not alter our core results. As a robustness check, we also ran models with feature-specific technical capability measures that were created using a smaller, focused set of patent classes for each feature and the results were similar.

Controls for experience with other imaging-related products had a significant effect in some cases. Not surprisingly, a firm's presence in dedicated webcams was a positive and significant factor that more than tripled the likelihood that a firm would introduce a camera with webcam capability. Presence in the webcam market significantly decreased the likelihood of introducing an LCD display, optical zoom, digital zoom, and removable storage. Since webcams had no LCDs, zoom lenses or removable storage, firms present in this market may have had a diminished belief in the value of these features.

Other firm controls had the expected effects for almost all seven product features. With the exception of the optical zoom feature, the more digital cameras a firm had on the market in a given year, the more likely it was to introduce a camera with a particular feature. *Firm size* had a significant effect on introduction of two features, and whether headquarters are *outside the US* had a significant effect on only one feature. Whether a firm is *public* had no effect on entry into any features. Exclusion of these variables from the models does not change the primary results. A likelihood ratio test comparing models that incorporated only control variables with models reported in table 6 showed a significant improvement in fit, and coefficients on the control variables were consistent across models. (These results are not shown for space considerations.)

Table 7 shows the results of analyses using negative binomial count models to test hypothesis 3, assessing whether firm experience with a feature diminishes the influence of prior industry on the continued introduction of models with specific digital camera features.

----------------------------------- Table 7 about here ----------------------------------

Models 1 - 5 in table 7 show strong support for hypothesis 3. For the optical zoom, digital zoom, movie clips, and removable storage features, the effect of other firms from the same prior industry being present in a feature diminished as a firm gained experience with the feature as indicated by the negative and significant coefficient on the interaction term (between *Firms from same prior industry present in feature* and *Firm feature experience*), and for LCD displays the interaction effect was marginally significant. For instance, for the optical zoom feature, the marginal effect of one more firm from the same prior industry present in the market was to increase a firm's count of optical zoom cameras by 13.8% if the firm had previously introduced only one product with optical zoom, but if the firm had introduced ten products with optical zoom, the marginal effect of one more peer firm decreased to 9.4%. Similarly, for movie clips, the marginal effect of an additional firm from the same prior industry went from a 7.8% increase to a 3.7% increase in movie clip cameras when a firm's experience with movie clips increased from 1 to 10 products. Once a firm gains its own experience with a product feature, beliefs based on prior industry experience become less important, and the actions of firms from the same prior industry have less impact. For the dual webcam feature (model 6), a firm's prior experience with the feature had the strongest influence on ongoing commitment. The effect of prior experience was negative and significant as one would expect since the dual webcam feature does not become part of the dominant design and is present in only 13% of new cameras by 2006.

We next examine hypotheses 3 in the context of resolution. Once a firm has introduced a camera with higher than VGA resolution, and has increasing access to information about customers' requirements for resolution given their desired use of digital images, we would expect that the introduction of increasingly higher resolutions (2MP, 3MP, 4MP, etc.) would be less influenced by the adoption of other firms from the same prior industry. As seen in table 7, model 7, firm experience, measured as a firm having previously entered a megapixel generation, had a strong positive effect on the likelihood of entry into a higher megapixel generation. The interaction between *Firms from same prior industry present in feature* and *Firm experience* was also significant and negative (hazard ratio coefficient less than one) indicating that the effect of *Firms from the same prior industry present* in a megapixel generation decreases if a firm has previously entered with a megapixel camera, thus supporting hypothesis 3.

Other controls were in the expected direction, with overall number of models a positive and significant predictor of a firm's introductions of digital cameras with particular features. A likelihood ratio test comparing the models in table 7 with models incorporating only the control variables showed a significant improvement in the model fit with the addition of our independent variables of interest and the interaction variable (these results are not shown here for space considerations).

To test the overall robustness of our results, we examined a number of alternative specifications and measures. To test hypotheses 1 and 2 regarding initial introduction of a feature, we also analyzed the data using a piecewise exponential model, which allows the hazard rate to vary across different time periods, and the main results did not change. For all models in tables 6 and 7, we tried defining the end of the period of ferment as 2002 instead of 2003, therefore excluding all years after 2002 (instead of 2003) and the results did not change. We also excluded Sony from the analysis, since, as a major component supplier for CCD chips, Sony's expertise may have played a role in the timing of their introduction of features, and again, the results were unchanged.

In summary, our results provided general support for H1. We found that concurrent introduction of a digital camera feature by other firms from the same prior industry was a significant predictor of entry into digital camera features, including LCD display, optical zoom, digital zoom, movie clips, and dual webcam, but not significant for the high resolution feature. We found mixed support for H2. Depending upon the feature, firms sometimes imitated other firms from the same prior industry in their choices of digital camera features. Hypothesis 3 was also supported. We found that the influence of adoption by other firms from the same industry decreased the more experience a firm has with a feature.

Addressing alternative explanations

We considered several possible alternative explanations for our results. First, although our setting is unique in that firms without technical capabilities could introduce features that were readily available through the supply chain, one could argue that firms that did have technical capability might be more likely to introduce a given feature. We therefore controlled for technological capabilities using firms' cumulative digital camera patenting. We found that technological capabilities did not have a significant effect on introduction of features and that our primary results still held. A second alternative explanation might be that some firms had greater power over their supply chain, and this affected access to particular features, thus influencing the timing of introduction. But as discussed earlier, in this setting there were multiple suppliers for each feature giving all firms access, and such power on the part of buyers is likely to correlate with firm size, which we control for in our models. In addition, one could ask whether it is shared beliefs driving our results or whether firms from the same prior industry are just pursuing similar approaches because these are appropriate (and will ultimately be correct). Our study addresses this in two ways: a) although firms from different industries pursued different approaches, it wasn't the case that a particular prior industry was always first in adopting the features that would eventually comprise the dominant design; and b) in the case of the dual webcam feature, firms in our study also pursued the 'wrong' feature (i.e. its inclusion in cameras initially rises but then decreases and it does not become part of the dominant design) and introducing this feature was also strongly driven by prior industry.

Finally, it is important to ask whether firms' choices about features to introduce reflect heterogeneity in their market positioning strategies or marketing capabilities -- that is, do they seek to serve particular customer niches or take advantage of particular distribution channels, which in turn affects their choices of features? Our findings suggest this is not the case. As discussed earlier, although there were distinct market niches in digital cameras, such as the professional and studio markets, or SLRs, that might correspond with different sets of features, we focus on firms' choices within the same mass market segment for digital cameras. So while marketing capabilities might influence a firm's decision to target the mass market as opposed to other segments, we control for that by evaluating choices within just the one segment. In addition, the distribution channels for mass market digital cameras included broad-based retailers such as Best Buy, that were already carrying analog cameras, computers, and consumer electronics such as camcorders and TVs. It is therefore not likely that firms introduced particular features primarily to take advantage of different distribution relationships. Moreover, despite heterogeneity in their initial choices of features, firms from all prior industries do converge on a standard constellation of features by 2004, suggesting that firms' strategic market positioning choices do not provide an explanation of this process. Thus, while all alternative explanations cannot be explicitly controlled for in our quantitative models, the preponderance of the evidence indicates that it is likely our results reflect the influence of shared beliefs and imitation arising from prior industry affiliation rather than an unobserved process that leads firms to initially introduce the same set of features.

DISCUSSION

New product markets sparked by technological change are characterized by high uncertainty, in particular about the characteristics that will ultimately emerge as part of a successful dominant design. In this context, managers, lacking concrete data about customer preferences, must develop initial product concepts based on their assumptions about the emerging market. But how do managers develop those assumptions and what explains the heterogeneity in their interpretations? Specifically, do firms from different industries differ systematically in the way in which their managers frame a new product concept in a nascent market? While prior empirical work has documented high technical variety during the early period of turbulence followed by technical convergence on a dominant design, it has not explored cognitive variety and convergence on a dominant product concept, as reflected in the product features firms introduce as part of the unfolding dominant design.

We explored these issues through an in-depth longitudinal study of the emergence of consumer digital cameras. Our findings, both descriptive and quantitative, show the important influence of a firm's prior industry affiliation on framing during the nascent stage of an industry. Qualitative data suggested that photography firms were more likely to frame a digital camera as an analog camera substitute, consumer electronics firms to frame it as a video system component, and computing firms to frame it as a PC peripheral. Quantitative analysis of the timing of product feature introductions reinforced the conclusions of our qualitative analysis. In particular, firms were more likely to introduce new product features concurrent with other firms from their prior industry, reflecting shared industry beliefs. The common understanding that firms develop when competing in an industry is thus an important source of firm heterogeneity when firms from multiple industries converge in a new industry. We also found that firms imitated other firms from the same prior industry in their introductions of some, but not all product features. Our results imply that firm choices in this instance arose both from common worldviews or mindsets that resulted in concurrent action as well as from social comparisons or mimetic behavior. In addition, we found that as firms developed experience with a product feature, the influence of industry background diminished. Thus, beliefs based on prior industry may be less deeply embedded than other beliefs and not a significant source of long term cognitive inertia.

Our study makes several contributions to research. A challenge in trying to understand the role of managerial cognition is that it is difficult to untangle managerial cognition from firms' capabilities. Behaviors that are assumed to result from managerial mindsets may in fact be driven by capabilities and vice versa. The nature of our setting allows us to take a major step towards disentangling the differential influence of these two factors. The digital camera features we studied could be introduced by firms with little or no technical capability due to the presence of a well-developed component supply chain and a set of OEM/ODM firms that could serve as system-level designers. Thus, firms could generally select from a menu of features offered by a range of existing suppliers. In addition, we used firm-level cumulative counts of patents to control for technological capabilities broadly related to digital imaging technologies. Thus, our setting and controls allowed us to study the outcomes of organizational perceptions about which features to include in a camera, while controlling for firm capabilities. Our results thus highlight a fundamentally different source of firm heterogeneity. While firm capabilities/resources are generally important in distinguishing why firms behave differently, we find that managerial beliefs associated with industry experience are also a key factor in how firms approach new product markets. Examining both capabilities and beliefs is thus important when evaluating the competitive landscape, and research that focuses only on capabilities or only on beliefs, may reach spurious conclusions. Similarly, managers that focus only on competitors' capabilities may be blinded to differences in how firms apply their capabilities if they don't also consider the assumptions and beliefs that those firms bring to the table.

Our work also contributes to research on technological evolution, specifically illuminating the processes that underlie cognitive convergence on a dominant design. Despite demand-side features being an important part of the theory behind emergence of a dominant design, prior empirical work has focused almost exclusively on tracking how the selection of technologies unfolded in an emergent dominant design. We document variation and convergence in the demand-side product features associated with the new product category. Competing perceptions of what a digital camera would be used for and therefore what consumers would value converged on a standard set of features by 2004. Interestingly, the dominant frame reflected a combination of the features and usage occasions associated with the initial photography frame (removable storage), consumer electronics frame (LCD display and movie clips), and computing frame (digital zoom).

Industry convergence, which can occur when a new technology facilitates the blurring of boundaries between previously distinct industries, is a significant phenomenon, given the prevalence of digital technology in multiple industries (Greenstein and Khanna, 1997; Yoffie, 1997). But empirical research delving into the phenomenon is limited, with exceptions such as Gambardella and Torrisi (1998) who examine whether and how technological convergence is related to industry or market convergence, and Lee (2007) who explores the role of alliances and networks during periods of convergence. By tracking the dynamics of convergence in features that are initially introduced by firms from heterogeneous industries, we shed light on these processes.

These results also raise compelling questions for future research. In contrast to many settings, in the digital camera market start-up firms did not play a major role – few entered and of those that did, none became major players, raising questions about the conditions under which entrepreneurial opportunities exist. In the context of digital cameras it might be that the convergence of established firms from different backgrounds made it more difficult for start-ups to identify unoccupied niches or blind spots, resulting in less entry. It could also be that the complementary assets of the established firms, such as access to distribution, made it difficult for start-ups to compete (cf. Tripsas, 1997). More work in settings that represent the convergence of multiple industries is needed to systematically address this question.

In cases where start-ups are a primary source of new technologies and features, it would be interesting to better understand what factors are responsible for the heterogeneity in approaches. Founders who spin off from established firms inherit knowledge (Klepper and Sleeper, 2005) and in the medical device and automobile industries have been found to outperform other entrants (Klepper, 2002; Chatterji, 2009). Founders' backgrounds have also been found to have a lasting influence on firm characteristics such as employment models (Baron, Hannan, and Burton, 1999). But this raises the question of whether founders also inherit industry mindsets, and if so, how does that influence both how start-ups conceptualize a new industry and ultimately how they perform?

This study has focused on a specific product market that is part of a broader network characterized by inter-firm modularity. Digital cameras do not operate in isolation, but are part of a system that includes scanners, printers, software, imaging websites, and memory cards among other elements. The emergence of a broader digital imaging industry architecture – where modular boundaries are drawn and where in the system firms compete – is an important aspect of new industry emergence (Jacobides, Knudsen, and Augier, 2006; Baldwin, 2008; Santos and Eisenhardt, 2009). An interesting avenue for future research would be to examine how different firm backgrounds influence the preferred industry architecture.

Another valuable area for future work is to better understand the implications of prior industry affiliation for firm performance. While research has addressed the role of capabilities stemming from prior industry experience, our theoretical and empirical understanding of what influences performance when firms with distinct industry mindsets converge on a new domain is much more limited. In addition, prior research has examined how adoption of the dominant design affects firm survival (Suarez and Utterback, 1995; Christensen *et al.*, 1998), but this work has focused on the technical dimension of a dominant design. An interesting extension would be to explore how the adoption – and timing of adoption – of the features that emerge as part of the dominant design affects both firm performance and survival. Related to this question is the issue of whether and how firms can influence which features become part of the dominant design. Existing research has focused on how firms can influence technological variants, but it may be just as important to proactively shape customer perceptions of a new product domain and thus impact what product framing becomes dominant. We hope that this paper inspires additional research on these important questions.

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FIGURE 1- Percentage of new cameras with feature, by year

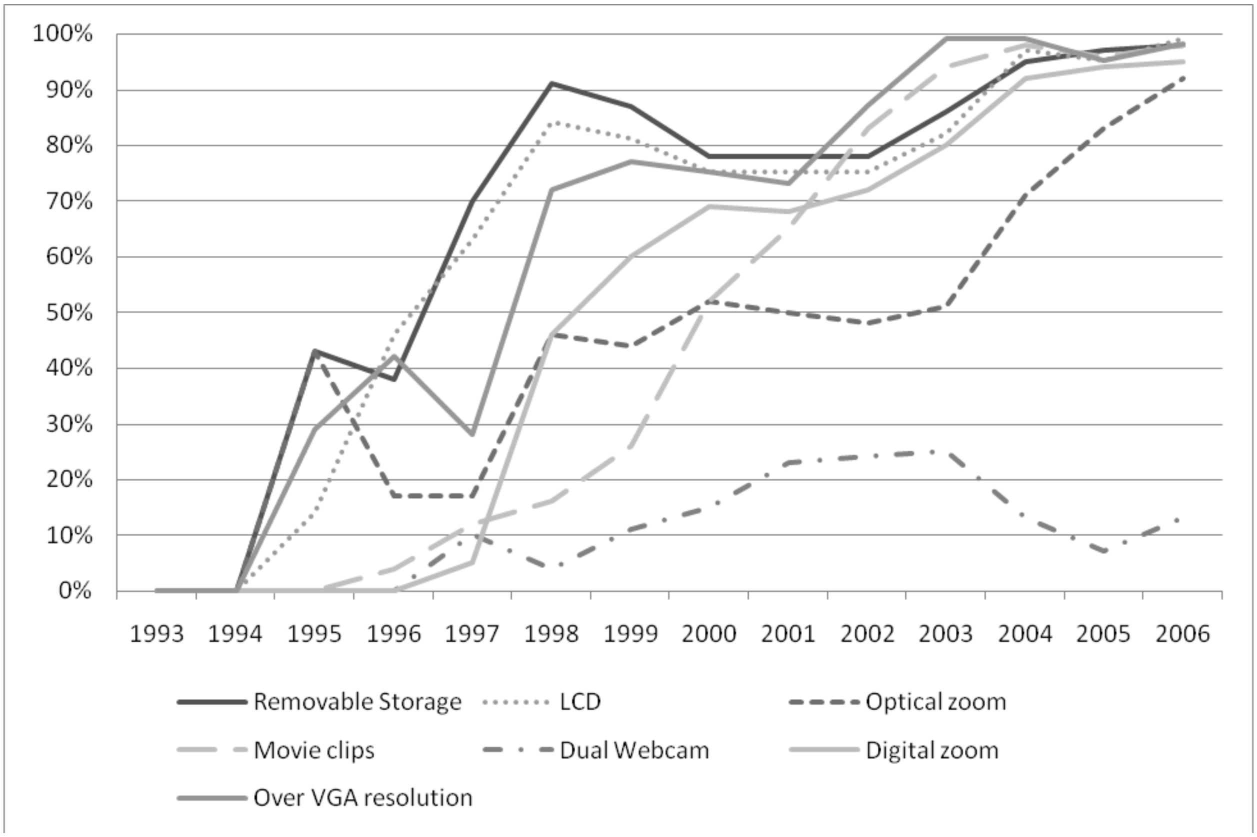

Table 1.Prior industry affiliation of firms that entered the consumer digital camera market

Photography	Consumer Electronics	Computing
Achiever	Archos	Aiptek
Agfa	Casio	Apple
Argus	Creative	BTC
Canon	DXG	BenQ
Chinon	Hitachi	D-Link
Concord	JVC	Dolphin
Fuji Photo Film	LG Electronics	Epson
Jazz Photo	Mitsubishi	Gallant Computer
Kodak	Oregon Scientific	Gateway
Konica	Panasonic	Hawking Technology
Kyocera	Philips	Hewlett-Packard
Leica	RCA	IO Magic
Minolta	Relisys	Intel
Minox	Samsung	Jenimage
Nikon	Sanyo	KB Gear
Olympus	Sharp	Logitech
Pentax	SiPix	Micro Innovations
Polaroid	Sony	Microtek Labs
Praktica	Syntax Brillian	Mustek
Premier		NEC
Ricoh		Soundvision
Ritz Camera		Spot Technology
Rollei		Toshiba
Sigma		UMAX Technologies
Vivitar		Visioneer

Table 2. Digital camera patent classes included in controls for technical capabilities

250	Radiant Energy
257	Active solid-state devices
324	Electricity: measuring and testing
327	Misc active electrical nonlinear devices, circuits, and systems
345	Computer Graphics Processing, operator interface processing, and selective visual display systems
348	Television
355	Photocopying
356	Optics: Measuring and Testing
358	Facsimile and static presentation processing
359	Optics: Systems (Including Communications) and elements
360	Dynamic Magnetic Information Storage or Retrieval
361	Electricity: electrical systems and devices
377	Electrical pulse counters, pulse dividers, or shift registers: circuits and systems
378	X-ray or gamma ray systems or devices
382	Image analysis
386	TV signal processing for dynamic recording or reproducing
396	Photography
428	Stock material or misc articles
430	Radiation imagery chemistry: process, composition, or product thereof
438	Semiconductor device manufacturing: process
711	Electrical computers and digital processing systems: memory
725	Interactive video distribution systems

Table 3. Summary of Digital Camera Features

Feature	Description	First year feature was introduced / Firm(s) that introduced it	Year >50% of new models have feature	Percent of models with feature in 2006
Dominant Design	Model contains all elements of the dominant design: LCD display, optical zoom, digital zoom, movie clips, overVGA resolution, and removable storage	1999 Sony, Casio, Toshiba	2004	88%
Optical zoom	Instead of a lens with a fixed focal length, the camera incorporates a zoom lens with a range of focal lengths	1992 Fuji	2000	92%
Removable storage	Incorporates a slot for memory (typically a flash memory card) that can be removed to transfer images to a PC or printer.	1992 Fuji	1997	97%
Greater than VGA resolution	Camera sensor captures more pixels than the VGA (640x480) resolution of a computer display	1995 Kodak	1998	98%
LCD Display	Inclusion of an LCD display that allows the user to see an image before taking a picture and preview / selectively delete pictures after image capture	1995 Casio	1997	99%
Movie clips	Ability to capture and store short video clips	1996 Ricoh	2000	98%
Digital zoom	Software manipulation of the image within the camera to create a "close-up," which is a cropped version of the original image	1997 Fuji, Epson, Hitachi	1999	95%
Dual webcam	Ability of a digital camera to switch to a webcam mode in which it enables real time streaming video through a PC	1997 Apple, Soundvision, UMAX, Ricoh, Vivitar	Never (peak 24% in 2002)	13%

Table 4. Adoption of digital camera features, by prior industry

(Shading indicates early adoption of the feature)

Feature	Photography Industry Firms (analog camera substitute frame)	Computer Industry Firms (video system component frame)	Consumer Electronics Firms (PC-peripheral frame)
Optical zoom			
First year introduced	1992	1998	1996
Year >50% new models have attribute	1998	2004	1999
Removable Storage			
First year introduced	1992	1997	1996
Year >50% new models have attribute	1995	1997	1997
Greater than VGA resolution			
First year introduced	1995	1995	1996
Year >50% new models have attribute	1996	1998	1998
LCD Display			
First year introduced	1996	1996	1995
Year >50% new models have attribute	1997	1998	1996
Movie Clips			
First year introduced	1996	1997	1997
Year >50% new models have attribute	2001	2001	1999
Digital zoom			
First year introduced	1997	1997	1997
Year >50% new models have attribute	1999	1998	1998
Dual Webcam			
First year introduced	1997	1997	1998
Peak adoption	17% in 2001	48% in 2001	20% in 2002

Table 5. Descriptive statistics

Feature	***LCD display***		***Optical zoom***		***Digital zoom***		***Over VGA res***		***Movie clips***		***Remov storage***		***Dual webcam***	
Variables	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***
Firm entry into feature	0.141	0.349	0.107	0.310	0.127	0.334	0.138	0.346	0.153	0.360	0.164	0.371	0.090	0.287
Firm experience in feature	3.912	7.751	2.223	5.564	2.542	6.030	1.850	3.270	1.884	4.466	4.079	7.803	0.585	1.609
Concurrent entry, same prior industry	2.110	2.647	1.672	1.164	2.141	2.169	2.031	1.240	2.497	1.922	2.345	2.043	1.480	1.345
Concurrent entry, diff. prior industry	4.621	4.102	3.398	2.082	4.768	3.906	4.605	1.873	5.729	3.342	5.517	3.626	3.712	2.572
Cumulative prev. entry, same prior ind.	9.249	6.424	7.339	5.980	6.444	6.424	9.124	6.363	7.308	6.680	11.429	6.811	4.153	4.303
Cumulative prev. entry, diff. prior ind.	17.345	10.486	14.028	9.182	12.009	10.370	17.917	11.776	15.581	14.044	23.205	13.463	9.316	8.869
Firms from same prior industry w/ feat	9.384	5.570	7.121	4.681	7.322	5.797	7.681	4.101	7.573	5.933	10.328	5.194	4.085	3.331
Firms from different prior ind. w/ feat	17.695	9.191	12.876	6.909	14.130	10.213	15.325	7.467	16.282	12.342	20.655	9.592	9.845	7.836

Controls	Mean	SD
Firm Size (log)	5.054	2.858
Non-US HQ	0.686	0.465
Firm models on market	5.347	5.803
Public	0.720	0.449
In webcams	0.153	0.360
In camcorders	0.246	0.431
In SLRs	0.161	0.368
Breadth of digital imaging offerings	1.158	1.227
Technical capability (ln patents)	3.882	2.269

Table 6. The influence of prior industry shared beliefs and imitation on introduction of digital camera features, Cox Hazard Model

	COEFFICIENT	(1) LCD display	(2) Optical zoom	(3) Digital zoom	(4) Over VGA resolution	(5) Movie clips	(6) Removable storage	(7) Dual Webcam capability
H1	Shared beliefs: concurrent entry by other	1.224***	1.674***	1.340***	1.232	1.449***	1.297***	1.874***
	firms from ***same*** prior industry	(0.0653)	(0.281)	(0.0984)	(0.171)	(0.152)	(0.0872)	(0.307)
	Concurrent entry by firms from a	0.986	0.976	1.036	0.898	1.031	0.997	1.088
	different prior industry	(0.0414)	(0.123)	(0.0510)	(0.0986)	(0.0694)	(0.0407)	(0.178)
H2	Imitation: Cumulative previous entry by	1.094**	1.077	1.166***	1.119**	0.915	1.007	1.032
	firms from the ***same*** prior industry	(0.0450)	(0.0542)	(0.0435)	(0.0595)	(0.0589)	(0.0324)	(0.0909)
	Cumulative previous entry by firms	1.021	0.983	1.026	0.982	1.083***	1.017	1.026
	From a ***different*** prior industry	(0.0197)	(0.0311)	(0.0246)	(0.0202)	(0.0303)	(0.0166)	(0.0435)
	Controls: Presence in related markets							
	Firm present in webcam market in year t	0.385***	0.181**	0.236**	0.978	0.657	0.270***	2.932***
		(0.142)	(0.139)	(0.151)	(0.306)	(0.237)	(0.0904)	(1.190)
	Firm present in camcorder market in year t	1.335	1.967	1.068	1.823	1.252	2.140*	0.959
		(0.634)	(1.139)	(0.555)	(0.706)	(0.417)	(0.912)	(0.810)
	Firm present in digital SLR market in year t	0.402	0.332	0.369*	0.176***	0.270**	0.641	0.149**
		(0.235)	(0.254)	(0.217)	(0.109)	(0.180)	(0.256)	(0.128)
	Breadth in other digital imaging products	1.299	0.925	1.257	1.432*	0.974	1.247*	0.842
		(0.245)	(0.213)	(0.298)	(0.266)	(0.125)	(0.148)	(0.215)
	Other firm controls							
	Firm models on market in year t	1.183***	1.074	1.142***	1.359***	1.137***	1.293***	1.099**
		(0.0623)	(0.0803)	(0.0504)	(0.0615)	(0.0385)	(0.0503)	(0.0467)
	Firm size (ln)	1.266**	1.297	1.416**	0.972	1.035	1.085	0.879
		(0.132)	(0.210)	(0.248)	(0.0926)	(0.0981)	(0.109)	(0.130)
	Public company	0.934	0.811	0.418	1.057	1.225	0.711	1.162
		(0.321)	(0.448)	(0.237)	(0.438)	(0.439)	(0.200)	(0.588)
	Non-US HQ	1.226	1.245	2.010**	1.203	1.223	0.984	1.025
		(0.386)	(0.562)	(0.646)	(0.420)	(0.371)	(0.256)	(0.366)
	Technical capability (ln patents)	0.895	1.040	0.922	1.101	0.939	0.866	1.055
		(0.0903)	(0.109)	(0.114)	(0.105)	(0.0658)	(0.0784)	(0.160)
	Observations	147	211	143	153	173	144	192
	No._fail	49	37	42	47	53	57	27
	Log likelihood	-142.8	-104.3	-115.9	-134.2	-149.6	-164.8	-73.99
	No. firms	65	65	61	64	64	65	59

Dependent variable: firm initial introduction of a feature, Robust standard errors in parentheses, Coefficients are hazard ratios, *** p<0.01, ** p<0.05, * p<0.1,

Table 7. Firm ongoing commitment to a feature: The effect of firm feature experience and prior industry affiliation

		Negative binomial model with random effects: Annual count of firm new models with feature						Cox Hazard model+
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Variable	LCD	Optical zoom	Digital zoom	Movie clips	Removable storage	Dual webcam capability	Megapixel generations
	Firms from **same** prior industry present in feature	-0.005	0.110***	0.022	0.050**	0.044***	0.032	1.051
		(0.016)	(0.029)	(0.015)	(0.021)	(0.016)	(0.052)	(0.0837)
	Firm experience in feature (cumulative models t-1)	0.014**	-0.005	0.009	-0.011	0.011**	-0.127**	7.536***
		(0.005)	(0.011)	(0.007)	(0.012)	(0.006)	(0.056)	(5.083)
H3	Firms from same prior industry present in feature X	-0.002*	-0.004**	-0.002**	-0.004**	-0.002***	0.026	0.847*
	Firm experience in feature	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.019)	(0.0727)
	Firms from **different** prior industry present in feature	0.004	0.044**	0.003	0.023**	0.014*	0.008	0.830***
		(0.008)	(0.017)	(0.008)	(0.011)	(0.007)	(0.030)	(0.0409)
	Controls: Presence in related markets							
	Firm present in webcam market in year t	-1.061***	-1.073***	-1.110***	-0.845***	-1.045***	-0.046	0.626
		(0.197)	(0.338)	(0.263)	(0.219)	(0.210)	(0.265)	(0.339)
	Firm present in camcorder market in year t	-0.024	-0.024	-0.024	0.310	0.174	0.517	0.574
		(0.139)	(0.268)	(0.152)	(0.201)	(0.148)	(0.519)	(0.339)
	Firm present in digital SLR market in year t	-0.142	-0.127	-0.067	-0.229	-0.180		0.654
		(0.130)	(0.192)	(0.143)	(0.182)	(0.136)		(0.257)
	Firm breadth in digital imaging	0.036	0.149	-0.012	-0.013	0.052	0.087	0.860
		(0.048)	(0.091)	(0.056)	(0.071)	(0.052)	(0.215)	(0.164)
	Other firm controls							
	Firm size (ln)	0.015	0.137	0.070	-0.013	0.017	-0.247***	1.020
		(0.044)	(0.086)	(0.050)	(0.053)	(0.045)	(0.092)	(0.0295)
	Firm models on market in year t	0.073***	0.058***	0.072***	0.083***	0.071***	0.149***	1.132
		(0.008)	(0.013)	(0.008)	(0.011)	(0.008)	(0.029)	(0.210)
	Public company	-0.091	0.226	-0.104	-0.065	-0.196	0.602*	1.252
		(0.130)	(0.258)	(0.145)	(0.187)	(0.128)	(0.330)	(0.478)
	Non-US HQ	0.159	0.219	0.247	0.185	0.180	0.647*	0.773
		(0.214)	(0.409)	(0.239)	(0.255)	(0.199)	(0.331)	(0.495)
	Technical capability (ln patents)	0.036	0.038	0.016	0.061	0.042	-0.308**	1.118
		(0.031)	(0.051)	(0.032)	(0.046)	(0.033)	(0.131)	(0.0860)
	Constant	1.804**	13.023	1.962*	12.787	0.905	8.659	
		(0.811)	(445.816)	(1.138)	(353.258)	(0.553)	(36.870)	
	Observations	172	130	122	126	191	74	440
	Number of firms	37	31	35	44	46	27	59
	Log likelihood	-330.3	-225.0	-245.2	-232.2	-355.0	-87.14	-316.6

+ Marginal risk of entry into 2MP, 3MP 4MP & 5MP, stratified by MP generation and clustered by firm, coefficient is hazard ratio

*** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses