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The Role of Pre-Entry Experience, Entry Timing, and Product Technology Strategies in Explaining Firm Survival

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Studying the U.S. personal computer industry from its inception in 1974 through 1994, we address the following questions. What product technology strategies increase the survival chances of entrants into new, technologically dynamic industries? Does the effectiveness of these strategies differ by pre-entry experience? Does the effectiveness of these strategies differ by when firms enter a new industry? Consistent with the published literature, we find that diversifying entrants have an initial survival advantage over entrepreneurial startups. But, we find the reverse for later entrants: startups that enter later in the industry have a survival advantage over the later entering diversifying entrants. We explain this finding in terms of the firms' product technology strategies (i.e., offering products based on the technology standard and products incorporating the latest technology), pre-entry experience, and entry timing. Our findings highlight that it is crucial to study what firms do after they enter a new industry to more completely understand their ultimate performance.

Key words: innovation; industry evolution; marketing; diversifying entrants; entrepreneurial startups
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1. Introduction

What product technology strategies increase survival of entrants into new, technologically dynamic industries? Does the effectiveness of these strategies differ by pre-entry experience? Does the effectiveness of these strategies differ by when firms enter a new industry? Providing answers to these questions has long been of interest to researchers in the marketing, management, strategy, and economics disciplines. However, a complete understanding of why some entrants into new industries ultimately fail is still lacking.

The traditional viewpoint in industrial organization is that new industries follow the product life cycle pattern: an initial period of intense competition, significant entry and exit of firms, and fragmented market shares is eventually followed by a shakeout in which the number of firms dramatically falls, leading to higher industry concentration (Gort and Klepper 1982). This pattern is consistent with the technology management literature that maintains there is a shift over the product life cycle from product to process innovation as a dominant design emerges (Utterback 1994, Christensen et al. 1998). Under these industry conditions, firms with the lowest costs grow to be bigger, and firms with the lowest costs are those with pre-entry experience and those that enter early (Klepper 1996, 2002). Empirical research demonstrates that pre-entry experience, time of entry, and exploitation of scale economies are crucial determinants of firm survival in traditional shakeout industries (Carroll et al. 1996, Klepper and Simons 2000).

We seek to extend this literature by also considering the implications of post-entry product technology strategies on firm survival. To do this, we focus on the exit behavior of firms and do not consider the firm entry decision. Moreover, our approach does not involve the use of structural models; instead, we follow the research stream employing reduced-form models of firm survival (Carroll et al. 1996, Christensen et al. 1998, Klepper and Simons 2000, Agarwal et al. 2002). Although our approach does not allow us to fully consider the selection problem caused by the endogeneity of entry and exit decisions, our reduced-form model does enable the study of a rich set of behaviors that may inform the development of new structural models (see Chintagunta et al. 2006, Caves 2007).[1] We empirically study the relationship between firm survival and the product technology strategies employed by diversifying entrants and entrepreneurial startups, while controlling for key corporate demographic effects. We examine these effects in a technologically dynamic setting, i.e., a new industry characterized by the simultaneous availability of successive generations of improved product technologies. Our emphasis is on the potential conditioning effects of pre-entry experience and entry time on the relationship between product technology strategies and firm survival.

The empirical setting for our study is the U.S. personal computer industry in the 1974–1994 period. The personal computer industry has been one of the most innovative, and most competitive, sectors of the economy. It provides a rich and dynamic context for studying product strategies and firm survival (Steffens 1994, Bayus 1998). Entrants into this new industry included diversifying entrants (e.g., IBM, HP, TI, and Tandy/Radio Shack), as well as entrepreneurial startups (e.g., Apple, Compaq, Dell, and Gateway). Prominent features of the personal computer industry are the availability of multiple, overlapping product technologies at any point in time, rapidly advancing technology, frequent new product introductions, ease of firm entry and exit, and the inability of any single firm to establish a long-term competitive advantage. Few industries have attracted large-scale investments by both entrepreneurial startups and diversifying entrants, and sustained entry well past the establishment of the dominant design. Clearly, focusing on a single, unique empirical setting like the personal computer industry does not allow us to establish a set of generalizable findings. At the same time, however, the personal computer industry affords us a rare opportunity to empirically study the effects of pre-entry experience and post-entry product technology strategies on firm survival and to develop results that can motivate studies in other industry contexts.

Consistent with the published literature, we find that diversifying entrants have an initial survival advantage over entrepreneurial startups. But, we find the reverse for later entrants: startups that enter later in the industry have a survival advantage over the later entering diversifying entrants. We explain this result by demonstrating that the product technology strategies related to higher survival rates differ by entry time and pre-entry experience. In the early years of a new industry before product standards are set, there are several alternative product technologies from which entrants can choose. Many entrants will not initially select the product technology that eventually becomes the standard, and thus they have high risks of failure. Among these early entrants, diversifying entrants are better able than startups to migrate to the product standard once it is known. As a result, the early diversifying entrants have higher survival rates than the early entering startups. Once the standard is established, however, survival depends on introducing products with the latest technology. Many later entrants are initially attracted by the higher sales volumes associated with "popular" products that are typically based on "older" product technology. Among these later entrants, startups tend to be less concerned than diversifying entrants about cannibalizing their line with products based on newer technology. Because they are more likely to introduce products with the latest technology as the industry evolves, later entering startups have higher survival rates than later entering diversifying entrants.

2. The Personal Computer Industry

Our information on the U.S. personal computer market comes from International Data Corporation's (IDC) *Processor Installation Census*.[2] Details of the data are discussed in a later section. As shown in Figure 1, the personal computer industry has witnessed rapid growth since its inception in 1974. Personal computer sales grew from a few thousand units in 1975 to over 18 million by 1994. The number of competitors in this industry steadily grew between 1974 and its peak of almost 250 firms in 1989. Since 1983, there have been over 100 competing firms in this industry in any given year. Not surprisingly, the proliferation of advanced technology has encouraged frequent new product introductions.[3] Moreover, significant entry and exit occurs in this industry throughout the time period of our study (see Figure 2). The availability of

[1] Recent work on Markov perfect industry dynamics offers a promising avenue to the development and estimation of structural models that endogenize the entry, exit, and technology investment decisions (e.g., see Ericson and Pakes 1995, Doraszelski and Pakes 2007, Macieira 2006).

[2] A personal computer is defined as a general-purpose, single-user machine that is microprocessor based and can be programmed in a high-level language. In our study, personal computers include all desktop, tower, notebook, and laptop computers (excluding workstations) selling for less than $15,000. IDC is the oldest among the various companies that tracks the computer industry and is widely respected as having an accurate picture of the activity in this industry.

[3] In our study, new products are the different manufacturer defined model names. Manufacturers generally use unique model names for personal computers with different CPUs (central processing unit), and incur significant expenses with the production and launch of new models (Steffens 1994). Multiple memory, display, sound, and communication configurations are possible within each brand model name, and can be changed at the time of purchase or even later. New products in our study are the unique brand models, not the varying configurations within a brand model (see also Bayus 1998).

Figure 1 The Personal Computer Industry

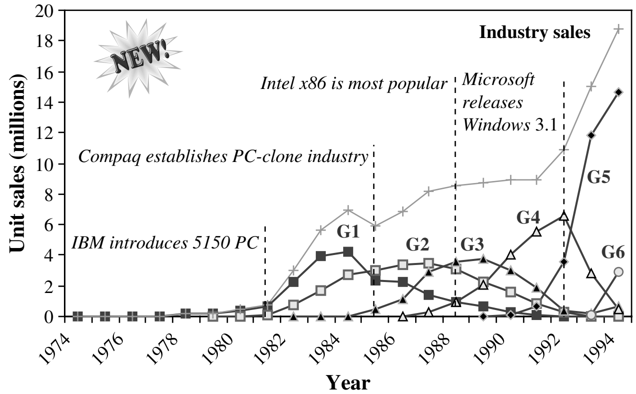
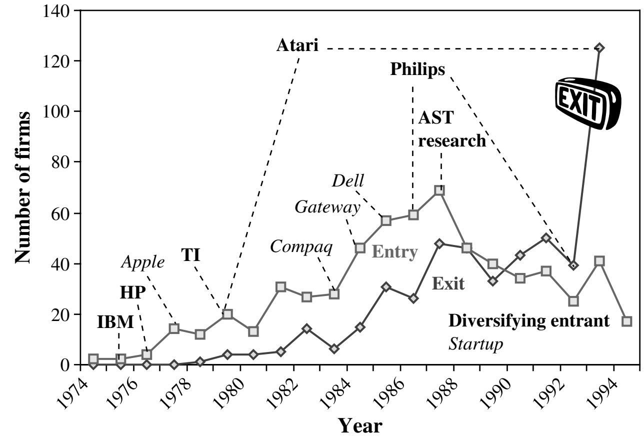


Figure 2 Firm Entry and Exit in the Personal Computer Industry



improving technology combined with intense competition has led to rapidly decreasing prices (Berndt and Rappaport 2001) and declining profit margins over time (Stavins 1995a, b). Overall, the personal computer industry follows the traditional life cycle pattern studied in the industrial organization literature.

Both hardware and software technology improved substantially over this twenty-one year period (Curry and Kenney 1999). Figure 1 shows unit sales associated with each successive microprocessor[4] technology generation (second generation technology became available in 1979, third generation in 1982, fourth generation in 1985, fifth generation in 1989, and sixth generation in 1993).[5] Each new microprocessor is associated with increased processing speed, enabling the development and use of more sophisticated operating systems, graphics, and application packages. As such, each new microprocessor generation entails high associated development and launch costs for manufacturers (Anderson 1995, Wade 1995). The curves in Figure 1 make it clear that sales of personal computers with older technology were dominant for a number of years after more advanced technology became available (e.g., even though more advanced second generation technology was available in 1979, sales of personal computers with second generation technology did not surpass sales of products with first generation technology until 1985).[6]

3. The Conceptual Framework and Hypotheses

We develop the conceptual framework that guides our research by first summarizing the existing literature on pre-entry experience, entry timing, and product technology strategies into four stylized facts. We then propose hypotheses involving the conditioning effects of pre-entry experience and entry timing on the product technology strategies and firm survival relationships. We argue that the effectiveness of these strategies is heterogeneous across firms' pre-entry experience, as well as firm entry time (i.e., the efficacy of a specific product technology strategy not only depends on *who* implements it, but also *when* it is employed).

3.1. The Effect of Pre-Entry Experience and Entry Timing on Firm Survival

Industry evolution and organizational research emphasize that entrant heterogeneity is an important factor affecting subsequent firm performance (Gort and Klepper 1982, Agarwal et al. 2002, Helfat and Lieberman 2002). To the extent that firms self-select so that the "better" firms always enter a new industry early, we expect to find that firm entry time dominates other explanatory variables in any empirical analysis. The literature, however, identifies additional potential sources of firm heterogeneity. In particular, pre-entry experience is important because founding conditions that imprint on an organization can have long-lasting effects (Stinchcombe 1965). We revisit the entry selection issue in §7.

[4] As discussed in Steffens (1994) and Anderson (1995), the most parsimonious way to describe the technology generations of personal computers is to compare their microprocessors or CPUs. The CPU is the brain of the computer because it contains the arithmetic and logic component, as well as the core memory and control unit for the computer. Thus, CPU design determines the computer's overall power and performance.

[5] We follow the common convention of distinguishing technology generations as follows (e.g., see *The PC Tech Guide* 2004): first generation (8-bit CPUs, including Zilog's Z80, Mostek's 6502, and Intel's 8080), second generation (e.g., Intel's 8088 and 8086, NEC's V20-40), third generation (e.g., Intel's 286, Motorola's 68000 and 68010), fourth generation (e.g., AMD and Intel's 386, Motorola's 68020), fifth generation (e.g., AMD and Intel's 486), and sixth generation (e.g., Intel's Pentium).

[6] Based on the IDC data, the most "popular" microprocessors in terms of sales were the following: 8080 (1974–1976), Z80 and 6502 (1977–1982), 6502 (1983–1984), 8088 (1985–1986), 286 (1987–1989), 386 (1990–1992), and 486 (1993–1994).

Stylized Fact 1: *Diversifying entrants have an initial survival advantage over entrepreneurial startups in new industries.* A nascent industry has very little industry-specific stock of knowledge (Gort and Klepper 1982), and thus has a malleable institutional environment. Diversifying entrants possess a wide range of resources and capabilities than can be leveraged into a new industry, including capital, organizational structure, technical and market knowledge, specialized skills, and experience from related activities (Helfat and Lieberman 2002). Moreover, the resource endowments of diversifying entrants enable them to leverage or develop collateral assets that help build market infrastructure and create customer demand in the emerging market (Teece 1986, Tripsas 1997). For example, IBM's introduction of their PC 5150 in 1981 helped to jump start the personal computer industry (see Figure 1). In the absence of industry-specific knowledge and legitimacy among consumers, the endowment and reputation effects of diversifying entrants during the early years act as a surrogate mechanism to tip the balance in their favor. Because these firms bring relevant experiences to help structure the uncertain marketplace, diversifying entrants have been found to have a survival advantage over startups during the early years of industry evolution (Klepper and Simons 2000, Klepper 2002).

Stylized Fact 2: *The initial survival advantage of diversifying entrants over entrepreneurial startups diminishes with entry time.* The changes that characterize industry evolution are documented across rich bodies of literature in technology management (Utterback 1994), organizational ecology (Carroll and Hannan 2000), and evolutionary economics (Gort and Klepper 1982). Evolution introduces a dynamic element because competition and customer demand changes as the industry matures and improved product technology becomes available (see Figure 1). In such dynamic environments, the importance of a diversifying entrant's pre-entry resources and capabilities may erode over time (Baum et al. 1994). Further, their relative lack of flexibility (Hannan and Freeman 1984), potential incompatibility of complementary assets (Teece 1986, Tripsas 1997), and internal politics (Pfeffer and Salancik 1978) means that the capabilities of diversifying entrants are slow to change. Empirical support comes from Teagarden et al. (2000) and Klepper (2002), who find that the relative survival advantage of diversifying entrants over startups is greater for firms that enter early rather than later in the industry life cycle.

3.2. The Effect of Product Technology Strategies on Firm Survival

In this study, we focus our attention on two types of product technology strategies that have been highlighted in extant literature as being critical determinants of long-run success. The first relates to the creation and adoption of a technology standard (Tushman and Anderson 1986, Utterback 1994, Teagarden et al. 2000) and the second relates to the introduction of new technology generations (Christensen 1997, King and Tucci 2002). Both product technology strategies have been very important in our empirical context. In the early years of the personal computer industry, for example, firms had a wide choice of microprocessors from manufacturers like Motorola, Intel, Mostek, Zilog, RCA, Texas Instruments, Rockwell, National Semiconductor, and Signetics. Although Intel's x86 CPU architecture was available in 1979, it was not until IBM introduced their PC 5150 with the Intel 8088 in late 1981 that Intel became the dominant CPU design for personal computers (Steffens 1994, Anderson 1995). By 1988, the Intel x86 architecture had become the industry standard as personal computer sales with an Intel x86 CPU represented over 50% of the market (Steffens 1994). In the later years of this industry, however, successive generations of improved product technology became available—meaning that firms must decide among the multiple overlapping product technologies involving "new" as well as "old" technology (see Figure 1).

Stylized Fact 3: *Firms offering products incorporating the product technology standard have higher survival rates than firms that do not.* The first commercialized forms of an innovation are typically primitive in nature (e.g., the first personal computer was "a box with blinking lights"). Competition in the early years of a new industry is primarily on the basis of continued product improvements (Gort and Klepper 1982, Agarwal and Bayus 2002). As a result, product variety increases as firms experiment with different and incompatible designs, technologies, and product combinations (Tushman and Anderson 1986). This variation is associated with high uncertainty about which technology will eventually become the product standard (Gabel 1991, Schilling 1998) or dominant design (Tushman and Anderson 1986, Utterback 1994). Many firms strive to establish their own product design as the technology standard in the industry because such dominance results not only in superior profits in the short run, but the ability to shape future generations of the product technology. In most industries, this battle for technology dominance results in a single-product architecture being widely accepted as the industry standard (Utterback 1994, Suarez 2004). Creating a dominant standard, or adopting it once it has been established, results in significant performance advantages. The increasing returns associated with network effects and technology lock-in (Arthur 1989), increased demand due to the development of complementary resources and products devoted to the technology standard (Wade 1995), and scale economies (Klepper 1996) suggest that survival is intimately related to whether or not a firm joins the bandwagon of firms, customers, and suppliers supporting a particular product standard (Wade 1995, Schilling 1998).

Stylized Fact 4: *Firms offering products incorporating the newest technology have higher survival rates than firms that do not.* The establishment of a dominant design results in a reduction of uncertainty, and a concomitant shift to economies of scale and market growth considerations (Christensen 1997, Mishina et al. 2004). Further, a prominent characteristic of technologically dynamic industries is the simultaneous availability of successive generations of improved product technologies (see Figure 1). In such environments, introducing products with the latest technology is important because otherwise a firm risks having an obsolete set of offerings (McGrath 2001). Firms applying practices, routines, and knowledge across product generations can gain a competitive advantage over firms that do not (Burgelman 1994, Iansiti and Clark 1994). Several empirical studies demonstrate that firms offering products incorporating the latest technology generations have lower mortality rates (Dowell and Swaminathan 2000, Jones 2003).

3.3. Pre-Entry Experience, Entry Timing, and Product Technology Strategies

As discussed above, the initial years of a new industry are fraught with uncertainty over which product technology will eventually become the standard. Despite this uncertainty, some firms will in fact select the technology standard at entry (in the personal computer industry, 34% of the startups and 33% of the diversifying entrants entering the industry before 1985 entered with a product incorporating the Intel x86 technology). Based on Stylized Fact 3, we expect that any firm entering a new industry with a product incorporating the technology standard will have higher survival rates than firms that do not. Moreover, for firms entering with the technology standard, there should be no difference in survival rates among the early entering startups and diversifying entrants. Thus, we have the following hypothesis.

Hypothesis 1 (H1). *Among the early entrants into a new industry entering with the product technology standard, there is no difference in the survival rates of diversifying entrants and entrepreneurial startups.*

At the same time, other early entrants into a new industry will not initially select what will become the product technology standard (in the personal computer industry, 66% of the startups and 67% of the diversifying entrants entering the industry before 1985 did not enter with a product incorporating the Intel x86 technology). In line with Stylized Fact 3, survival will depend on whether the firm can migrate to the technology standard. Here, we expect pre-entry experience to be important (Stylized Fact 1). As discussed by Kogut and Kulatilaka (1994), investments in multiple technology platforms when the eventual outcome is uncertain are real options. Given their need for higher sales and growth targets (Penrose 1959), as well as their prior experience in new product development (Meyer and Roberts 1986), diversifying entrants will have a higher valuation of the benefits versus costs of investing in these options. Diversifying entrants are also less likely to be overconfident about their original product technology choices, and therefore more willing than startups to consider alternative product technologies (Busenitz and Barney 1997). Startups may focus on a more narrow technological area (Meyer and Roberts 1986) or become locked-in to their product designs due to a lack of resources, knowledge, and experience to change them (Tushman and Anderson 1986, Teagarden et al. 2000). Together, these arguments indicate that among the firms not entering with the product standard, diversifying entrants will have higher survival rates than startups (because they are more likely to later migrate to the standard once it is known). Based on this line of reasoning, we propose:

Hypothesis 2 (H2). *Among the early entrants into a new industry not entering with the product technology standard, diversifying entrants have higher survival rates than entrepreneurial startups.*

After the product technology standard is established, the basis of competition shifts to product offerings involving the successively available technology generations that are usually targeted to different customer segments. Due to its importance (Stylized Fact 4), some firms will enter with products incorporating the latest available technology (in the personal computer industry, 19% of the startups and 16% of the diversifying entrants entering the industry after 1984 entered with a product incorporating the newest technology). From Stylized Fact 4, we expect that firms entering with a product incorporating the latest technology will have higher survival rates than firms that do not. Moreover, for firms entering with the newest technology, there should be no difference in survival rates among the early entering startups and diversifying entrants. Thus, we have the following hypothesis.

Hypothesis 3 (H3). *Among the later entrants entering with the newest product technology, there is no* *difference in the survival rates of diversifying entrants and entrepreneurial startups.*

At the same time, many new entrants in the later stages of an industry will be attracted to the more "popular" product technologies with high sales (in the personal computer industry, 81% of the startups and 84% of the diversifying entrants entering after 1984 did not enter with a product incorporating the newest technology). In line with Stylized Fact 4, survival in this case will depend on whether the firm also offers the latest technology. Here, we expect pre-entry experience to be important (Stylized Fact 2). As indicated earlier, the "popular" product technologies generally have higher sales volumes but involve older technology (see Figure 1). In this context, diversifying entrants face a paradox that is similar to the dilemma facing large incumbent firms that ignore the latest technological generations in their industry because it does not meet the needs of their mainstream customers (Christensen 1997). Indeed, Christensen (1997) highlights the fact that even though these firms had the capabilities, they *chose* not to pursue the new technology niches that had relatively low expected sales. Managerial rigidities and inertia have been linked to a lack of response by existing firms to new markets and technologies (King and Tucci 2002, Utterback and Kim 1986). Several researchers also point out that diversifying entrants are less willing than startups to risk cannibalizing the high sales volumes of their existing offerings because they want to spread their development and launch costs over as many units as possible. Thus, these firms often postpone the introduction of newer technology generations that have much lower sales (Nault and Vandenbosch 1996, Chandy and Tellis 1998). McGrath (2001) noted that cannibalization fears were pervasive in the computer industry and dictated the decisions of many large firms. Further, economic models involving niche segmentation (Caves and Porter 1977, Porter 1979) and organizational ecology models of resource partitioning (Swaminathan 1995) suggest that entrepreneurial startups can avoid direct competition by occupying strategic niches and fulfilling unsatisfied customer needs, as opposed to diversifying entrants who may have strategic disincentives to exploit these opportunities or may suffer from inefficiencies due to their large size. Together, these arguments indicate that among the firms not entering with the newest product technology, startups will have higher survival rates than diversifying entrants (because they are more likely to later offer products incorporating the latest technology). Accordingly, we have:

Hypothesis 4 (H4). *Among the later entrants not entering with the newest product technology, entrepreneurial startups have higher survival rates than diversifying entrants.*

4. Data and Variable Definitions

The population of U.S. personal computer manufacturers we study is based on a census listing from IDC of all domestic firms and foreign subsidiaries that built such products in the United States during 1974–1994.[7] Annual firm-level data were constructed from detailed product-level information in the IDC database. The resulting data set includes 3,083 firm-year observations for 623 personal computer manufacturers (78% of these firms exited before 1994). Summary descriptive statistics of our variables is in the appendix.

4.1. Firm Survival

Our dependent variable is the timing of firm exit from the personal computer industry. A firm is considered to have exited in year t if its unit sales for years $t+1$ to 1994 were zero; otherwise, the firm exit date was coded to be a right-censored observation. As noted by Stern and Henderson (2004), the personal computer industry is predominated by exits of single-business entities; the few multibusiness corporations (e.g., Tektronix) that exited were treated as failures. In this industry, acquisitions were infrequent and when they did occur, the acquired firm continued to operate as a distinct entity from the parent (e.g., even though AT&T acquired NCR in 1991, NCR was left intact; see Swanson 2002 and Stern and Henderson 2004).

4.2. Pre-Entry Experience

The data on pre-entry experience are primarily collected from the annual volumes of the *Thomas Register of American Manufacturers*. The *Thomas Register*, which dates back to 1906, is a national buying guide that has been used to study firm activity in the evolution of markets (Gort and Klepper 1982, Klepper 2002, Agarwal and Bayus 2002). In describing various sources of business information, Lavin (1992, p. 129) states that "the *Thomas Register* is a comprehensive, detailed guide to the full range of products manufactured in the United States. Covering only manufacturing companies, it strives for a complete representation within that scope."

Pre-entry experience was determined by matching each firm in the IDC database with its corresponding information in the *Thomas Register*. As in Agarwal et al. (2002), if a firm was listed in the index volumes of the *Thomas Register* for the year preceding its entry into personal computers, it was classified as a diversifying entrant. The resulting classifications were also confirmed using other data sources such

[7] This information is only available through 1994, because IDC changed to a more aggregate data collection format in 1995.

as Lexis/Nexis and the *International Directory of Company Histories.* Personal computer firms that did not appear in these sources before their inclusion in the IDC database were classified as a startup (e.g., Apple, Compaq, Dell, and Acer). As is typically the case in new industries (Carroll et al. 1996, Helfat and Lieberman 2002), the majority of entrants in the personal computer industry are entrepreneurial startups with no prior industry experience (almost 75% of the firms in our sample are startups). We define the binary variable *Diversifying Entrant* to be one if the firm is classified as having pre-entry experience, and zero if the firm is a startup.

To control for the heterogeneity among diversifying entrants, we include *Firm Age Before Entry* (measured as the number of years the firm was in existence at entry) in our analyses. This variable was constructed by identifying the first year in which each diversifying entrant appeared in the *Thomas Register* and confirmed with available company histories. Further, following Steffens (1994), *Thomas Register* information on the primary line of business was used to classify the pre-entry experience of diversifying entrants into a set of mutually exclusive binary variables involving technical experience and market experience (and "other experience"). Firms with *Only Technical Experience* include those in related product markets (e.g., mainframe or minicomputers, video games, typewriters, business machines) and/or technology markets (e.g., microprocessors or semiconductors), and account for 13% of the firms in our sample. Prominent examples include Atari, Hewlett Packard, and Texas Instruments. Diversifying entrants with *Only Market Experience* include those with knowledge of the potential customers for personal computers (e.g., retailers, consultants, manufacturers of peripherals), and account for 6% of the firms in our sample. Examples include Tandy/Radio Shack, Tandon, and Wyse. Firms with *Both Technical & Market Experience* include IBM, NCR, and Everex Systems (these entrants account for 5% of the firms in our sample).

4.3. Entry Timing and Corporate Demographics

Firm entry timing plays a prominent role in several studies examining the relationship between pre-entry experience and firm survival. For example, Teagarden et al. (2000) and Klepper (2002) find that the relative survival advantage of diversifying entrants is greater for firms that enter early rather than late. Much research has also considered the relationship between firm survival and the timing of its entry into the new industry (Lieberman and Montgomery 1998). In new, technologically dynamic industries, early entrants generally have higher survival rates than later entrants (Christensen et al. 1998, Sorenson 2000). Based on the product-level information from IDC, a firm's *Entry Time* into the personal computer industry is defined to be the year in which the firm first sold a personal computer (less 1973).

Following the organizational ecology literature, we also include several firm and industry controls in our analyses (Carroll and Hannan 2000). Because smaller firms typically have higher hazards of exit due to their capability and resource constraints, we include a variable *Firm Size* (measured as the firm's personal computer unit sales in the prior year divided by 10,000). Firm tenure in a new industry has also been found to be an important explanatory variable, so we include *Firm Age* (measured as the number of years the firm participated in this industry) and its square (to capture any nonlinear effects).

The theory of density dependence, based on the contrasting effects of legitimization and competition, postulates a U-shaped survival relationship to firm density: initial increases in the number of firms results in a decline of exit rates for all firms due to the legitimacy factors, but at higher levels of firm density, competitive effects intensify and exit hazard rates increase. Of course, if the competitive effects in a new industry dominate, firm survival is simply an increasing function of firm density. Related theory on founding density effects also predicts that density at time of new firm's founding is positively related to the hazard of exit. To account for these effects, we include *Density* (measured as the number of firms in the industry in the prior year), its square, and *Density at Founding* (measured as the number of firms in the industry in the year prior to the firm's entry year).

4.4. Product Technology Strategies

Two key aspects of a firm's product technology strategy are important for testing the hypotheses in §3.3. First, we need information on whether or not a firm offers products incorporating the technology standard during its tenure in the personal computer industry. To capture such effects, we define *Ever Offer Intel x86* to be one if the firm ever introduced a personal computer with a microprocessor involving the Intel x86 architecture, and zero otherwise. For the firms that eventually offered a product with the Intel x86 technology, we also consider whether there are any dynamic effects by defining *Cumulative Time in Market Without Intel x86* to be the cumulative number of years (up to the prior year) a firm does not offer a personal computer with the Intel x86 CPU (=0 for time periods before 1979 when the Intel x86 technology was unavailable and for time periods after the firm introduces a product with the Intel x86 technology; or if the firm never introduces the technology). We also define a mutually exclusive set of binary variables involving pre-entry experience and whether the firm entered or did not enter with the Intel x86 technology (*Startup Entering With Intel x86*, *Diversifying Entrant*

Entering With Intel x86, *Startup Not Entering With Intel x86*); here the baseline category is diversifying entrants not entering with the Intel x86 technology.

Second, we need information on whether or not a firm offers products with the latest technology. We define *Ever Offer Newest Product Technology* to be one if the firm ever introduced a personal computer using the newest (most advanced) microprocessor technology at the time, and zero otherwise. We also consider whether there are any dynamic experience effects by including *Cumulative Number of Newest Product Technology Generations Ever Offered* (measured as the cumulative number, up to the prior year, of the newest technology generations offered by the firm). Finally, we define a mutually exclusive set of binary variables involving pre-entry experience and whether the firm entered or did not enter with the newest technology (*Startup Entering With Newest Technology*, *Diversifying Entrant Entering With Newest Technology*, *Diversifying Entrant Not Entering With Newest Technology*); here the baseline category is startups not entering with the newest technology. See Figure 1 for the dynamically changing definition of "newest technology."

5. Estimation Methodology

While firms could exit at any point during the year, the IDC data were only updated annually, and thus the year of exit can be determined but not the exact month or day. Therefore, discrete-time survival models are most appropriate for our empirical study.

Following Jenkins (2005), the survivor function at the beginning of the tth interval is

$$S(t-1) = \Pr(T > t-1) = 1 - F(t-1). \qquad (1)$$

Here, the length of survival in the new industry is a realization of a continuous random variable T, and the failure function is $F(t) = \Pr(T \le t)$. Let us assume that the underlying continuous time model is summarized by the hazard rate $\theta(t, X \mid v) = v\theta(t, X)$, where t is firm age, X is a vector of independent variables (some of which may be time varying), and v is a random variable that captures unobserved heterogeneity between firms. The survivor function at the end of the tth interval is

$$S(t, X \mid v) = \exp\left[-v\int_0^t \theta(\omega, X)\, d\omega\right] = [S(t, X)]^v. \qquad (2)$$

We will also assume that the hazard rate satisfies the proportional hazard specification

$$\theta(t, X \mid v) = v\theta_0(t)\, e^{\beta X} = v\theta_0(t)\lambda. \qquad (3)$$

Together, (2) and (3) imply that

$$S(t, X \mid v) = \exp\left[-v\int_0^t \theta_0(\omega)\,\lambda\, d\omega\right] = \exp\left[-v\lambda\int_0^t \theta_0(\omega) d\omega\right] = \exp[-v\lambda H_t]. \qquad (4)$$

Here, H_t is the integrated baseline hazard evaluated at the end of the interval, and thus the baseline survivor function at age t is $S_0(t) = \exp(-H_t)$.

The discrete-time hazard function (i.e., the probability of exit in interval t, conditional on surviving up to the beginning of interval t) is then

$$h(t, X \mid v) = 1 - \frac{S(t, X \mid v)}{S(t-1, X \mid v)} = 1 - \exp[v\lambda(H_{t-1} - H_t)]. \qquad (5)$$

This further implies that

$$\log(1 - h(t, X \mid v)) = v\lambda(H_{t-1} - H_t), \qquad (6)$$

and thus

$$\log(-\log[1 - h(t, X \mid v)]) = u + \beta X + \log(H_t - H_{t-1}), \qquad (7)$$

where $u = \log(v)$. Similarly, the discrete-time baseline hazard for the tth interval is

$$1 - h_0(t) = \exp(H_{t-1} - H_t), \qquad (8)$$

and hence,

$$\log(-\log[1 - h_0(t)]) = \log(H_t - H_{t-1}) = \delta(t). \qquad (9)$$

In our analyses, we use a flexible, nonmonotonic quadratic functional form for $\delta(t)$. Together, (7) and (9) give the discrete-time (interval) hazard rate function we employ:

$$\log(-\log[1 - h(t, X \mid v)]) = u + \beta X + \delta_1 t + \delta_2 t^2. \qquad (10)$$

Here, the $\log(-\log(\cdot))$ transformation is known as the complementary log-log transformation and the discrete-time proportional hazards model in (10) is referred to as a random effects cloglog model. We assume that u has a normal distribution with mean 0 and variance σ^2, and thus for estimation purposes, we use the xtcloglog procedure implemented in STATA 9.0.

6. Estimation Results

Estimation results for the corporate demographic variables, as well as entry time and pre-entry experience, are in Table 1. Table 2 contains the hazard model estimation results for the product technology strategies, and Tables 3 and 5 report the results for the conditioning effects of entry time and pre-entry experience. We discuss each in turn.

Across all our analyses, we note that the estimates for σ are insignificant, indicating that unobserved heterogeneity is not important for our models. As noted

Table 1 Discrete-Time Estimation Results of Personal Computer Firm Exit and Pre-Entry Experience

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Diversifying Entrant		0.015 (0.131)	−0.844[b] (0.345)		
Diversifying Entrant × *Entry Time*			0.066[a] (0.024)		
Only Technical Exp.				0.048 (0.163)	−1.384[a] (0.519)
Only Market Exp.				0.091 (0.220)	−0.162 (0.647)
Technical & Market Exp.				−0.300 (0.266)	−1.867[b] (0.850)
Other Exp.				0.230 (0.305)	1.158 (0.902)
Only Technical Exp. × *Entry Time*					0.115[a] (0.038)
Only Market Exp. × *Entry Time*					0.018 (0.043)
Technical & Market Exp. × *Entry Time*					0.119[b] (0.060)
Other Exp. × *Entry Time*					−0.084 (0.075)
Controls					
Firm Age	0.242[a] (0.087)	0.242[a] (0.089)	0.227[a] (0.051)	0.254[a] (0.093)	0.256[a] (0.092)
Firm Age^2	−0.008[c] (0.004)	−0.008[c] (0.004)	−0.006[c] (0.004)	−0.008[b] (0.004)	−0.007[c] (0.004)
Firm Age Before Entry	−0.006[c] (0.004)	−0.007 (0.005)	−0.006 (0.005)	−0.007 (0.005)	−0.005 (0.005)
Firm Size	−0.230[a] (0.042)	−0.230[a] (0.042)	−0.226[a] (0.042)	−0.230[a] (0.042)	−0.218[a] (0.042)
Entry Time	0.219[a] (0.040)	0.219[a] (0.040)	0.118[a] (0.034)	0.221[a] (0.041)	0.200[a] (0.043)
Density	0.011[b] (0.005)	0.011[b] (0.005)	0.011[b] (0.005)	0.011[b] (0.005)	0.011[b] (0.005)
Density^2 ($\times 10^{-2}$)	−0.003[b] (0.001)	−0.003[b] (0.001)	−0.003[b] (0.001)	−0.003[b] (0.001)	−0.003[b] (0.001)
Density at Founding	−0.004[a] (0.002)	−0.004[a] (0.002)	−0.004[b] (0.002)	−0.004[a] (0.002)	−0.004[b] (0.002)
Unobserved heterogeneity (σ)	0.114 (1.057)	0.106 (1.166)	0.001 (0.464)	0.198 (0.673)	0.317 (0.430)
Constant	−4.969[a] (0.602)	−4.969[a] (0.610)	−4.658[a] (0.446)	−5.025[a] (0.626)	−4.870[a] (0.626)
Log-likelihood	−1,243.49	−1,243.48	−1,239.73	−1,242.11	−1,233.96
χ^2 (df)	114.11[a] (8)	114.02[a] (9)	154.19[a] (10)	112.83[a] (12)	113.02[a] (16)
N	3,083	3,083	3,083	3,083	3,083

Notes. Standard errors are in parentheses. [a]Significant at 0.01 level (2-tail); [b]significant at 0.05 level (2-tail); [c]significant at 0.10 level (2-tail).

by Jenkins (2005), any effects due to unobserved heterogeneity are mitigated by our use of a flexible hazard formulation and a wide range of explanatory variables. Additionally, all our results for the corporate demographic variables have precedents in the literature (Carroll and Hannan 2000). The personal computer industry is generally characterized by a strong competitive environment (the linear *Density* term is positive and significantly larger than *Density*^{2} or *Density at Founding*). The significant coefficient estimates for the linear and quadratic *Firm Age* terms imply that firms are subject to a liability of obsolescence, i.e., in dynamically changing industries, firms' initially successful alignment with its founding environment erodes with the passage of time due to structural inertia and the inability to make necessary adjustments (Carroll and Hannan 2000). This is also in line with the notion that in markets facing continuous technological change, vintage effects associated with older technology offset the benefits of experience, and that the inertia tendencies of older firms overshadow any learning-by-doing effects (Jovanovic and Nyarko 1996).[8] As firms age, they have to navigate more technology transitions and are thus subjected to higher risks of failure. This age effect, however, is counterbalanced by firm size: *Firm Size* is negatively related to exit and significant, i.e., firms that achieve and maintain a high level of sales in the new industry tend to have higher survival rates.

As expected, the estimated coefficient for *Entry Time* is positive and significant in Table 1. This implies that early entrants in the personal computer industry generally have higher survival rates than later entrants. Although pre-entry experience in Table 1, Model 2 (without the *Entry Time* interaction term) is insignificant, the more complete results in Model 3 are in line with Stylized Facts 1 and 2. The highly significant and positive estimate for *Diversifying Entrant*, combined with the negative interaction involving pre-entry experience and *Entry Time*, indicates that diversifying entrants have an initial survival advantage over startups in the personal computer industry (of about 12 years), but this advantage diminishes for later entrants. Not surprisingly, the results in Table 1, Model 5 indicate that firms with more directly relevant prior experience have higher survival rates than startups or firms with some other prior experience. Due to their high standard errors, the main and interaction coefficient estimates for *Only Technical Exp.*, *Only Marketing Exp.*, and *Technical & Marketing Exp.* are statistically equivalent ($\chi^2(2)_{\text{main}} = 3.27$, $p > 0.20$; $\chi^2(2)_{\text{interaction}} = 3.53$, $p > 0.17$). Thus, we emphasize

[8] We note that firm experience as measured by the cumulative number of products introduced is significant and positively related to firm survival in all our models (details are available from the authors).

Table 2 Discrete-Time Estimation Results of Personal Computer Firm Exit and Product Technology Strategies

Variables	Model 1	Model 2	Model 3	Model 4
Diversifying Entrant	−0.690[c] (0.404)	−0.842[b] (0.395)	−0.407 (0.379)	−0.797[b] (0.409)
Diversifying Entrant × Entry Time	0.055[b] (0.028)	0.083[a] (0.030)	0.035 (0.027)	−0.079[a] (0.031)
Ever Offer Intel x86	−1.703[a] (0.313)	−1.459[a] (0.176)		
Cumulative Time in Market Without Intel x86		−0.104 (0.115)		
Ever Offer Newest Product Technology			−1.915[a] (0.173)	−1.749[a] (0.148)
Cumulative Number of Newest Product Technology Generations Ever Offered				−0.013 (0.099)
Controls				
Firm Age	0.271[a] (0.103)	0.116[b] (0.060)	0.403[a] (0.073)	0.273[a] (0.066)
Firm Age^2	−0.006 (0.005)	0.002 (0.004)	−0.010[b] (0.004)	−0.003 (0.004)
Firm Age Before Entry	−0.004 (0.005)	−0.006 (0.005)	−0.008[c] (0.005)	−0.010[b] (0.005)
Firm Size	−0.198[a] (0.041)	−0.194[a] (0.039)	−0.189[a] (0.039)	−0.188[a] (0.039)
Entry Time	0.213[a] (0.044)	0.104[c] (0.054)	0.215[a] (0.038)	0.138[b] (0.058)
Density	0.018[a] (0.006)	0.017[a] (0.006)	−0.003 (0.006)	−0.001 (0.006)
Density^2 ($\times 10^{-2}$)	−0.004[a] (0.002)	−0.004[a] (0.002)	0.000 (0.001)	−0.000 (0.002)
Density at Founding	−0.002 (0.002)	0.001 (0.002)	−0.000 (0.002)	0.002 (0.002)
Unobserved heterogeneity (σ)	0.443 (0.355)	0.001 (0.327)	0.144 (0.399)	0.001 (0.539)
Constant	−4.950[a] (0.689)	−3.785[a] (0.525)	−3.791[a] (0.476)	−2.973[a] (0.537)
Log-likelihood	−1,196.09	−979.65	−1,121.25	−940.58
χ^2 (df)	119.08[a] (11)	164.35[a] (12)	232.64[a] (11)	243.26[a] (12)
N	3,083	2,462	3,083	2,462

Notes. Standard errors are in parentheses. [a]Significant at 0.01 level (2-tail); [b]significant at 0.05 level (2-tail); [c]significant at 0.10 level (2-tail).

the more parsimonious binary pre-experience variable *Diversifying Entrant* in our analyses.

We demonstrate that a firm's product technology strategy is significantly related to its survival in Table 2. The negative and highly significant coefficient estimates for *Ever Offer Intel x86* and *Ever Offer Newest Product Technology* indicate that these strategies are associated with higher survival rates. Consistent with Stylized Facts 3 and 4, we find that firms offering products with the (eventual) technology standard and products with the latest available technology have higher survival rates than firms not pursuing these strategies. The insignificant estimates for *Cumulative Time in Market Without Intel x86* and *Cumulative Number of Newest Product Technology Generations Ever Offered* suggest that there are no dynamic effects associated with these strategies.

To directly and parsimoniously test our hypotheses, we split our sample into "early" and "late" entrants based on *Entry Time*. We use 1985 as the dividing year for three reasons:[9] (1) from the results in Table 1, the survival advantage of diversifying entrants over startups reverses around year 12 (which translates into $1973 + 12 = 1985$), (2) the start of the fourth generation product technology (32-bit technology) occurs in 1985, and (3) 1985 was an important transition year in the personal computer industry: Intel decided to single source the manufacturing of its fourth generation 80386 CPU chip (i.e., it was only available from Intel); IBM chose to rely on earlier microprocessors to which it had manufacturing rights and to begin developing (with Microsoft) its new OS/2 operating system for the 286 system; and Compaq (a startup firm

[9] Similar results are obtained for other reasonable cut-points. In addition, models involving higher-order *Entry Time* interaction terms rather than separate models split by time period give the same conclusions.

Table 3 Discrete-Time Estimation Results of Personal Computer Firm Exit and the Conditioning Effects of Entry Time and Pre-Entry Experience: Testing H1 and H2

Variables	Model 1 (Entry 1974–1984)	Model 2 (Entry 1985–1994)
Startup Entering With Intel x86	−0.521[c] (0.312)	−0.737[c] (0.408)
Diversifying Entrant Entering With Intel x86	−0.451 (0.330)	−0.607 (0.402)
Startup Not Entering With Intel x86	0.489[b] (0.248)	−0.365 (0.508)
Test of coefficient equality (χ^2)		
H1: *Entering With Intel x86* (*Startup* = *Diversifying Entrant*)	0.05	0.43
H2: *Not Entering With Intel x86* (*Startup* = *Diversifying Entrant*)	3.89[b]	0.52
Controls		
Firm Age	0.080 (0.119)	0.323[a] (0.121)
Firm Age^2	−0.002 (0.006)	−0.013 (0.012)
Firm Age Before Entry	−0.010 (0.007)	−0.002 (0.007)
Firm Size	−0.157[a] (0.048)	−0.299[a] (0.070)
Entry Time	0.058 (0.169)	0.185[a] (0.042)
Density	0.014[b] (0.007)	0.161[a] (0.056)
Density^2 ($\times 10^{-2}$)	−0.003 (0.002)	−0.035[a] (0.011)
Density at Founding	0.005 (0.011)	0.001 (0.003)
Unobserved heterogeneity (σ)	0.001 (0.319)	0.556 (0.137)
Constant	−4.450[a] (0.801)	−22.724[a] (6.547)
Log-likelihood	−466.59	−752.04
χ^2 (df)	72.05[a] (11)	87.71[a] (11)
N	1,434	1,649

Notes. Standard errors are in parentheses. [a]Significant at 0.01 level (2-tail); [b]significant at 0.05 level (2-tail); [c]significant at 0.10 level (2-tail).

Table 4 Product Technology Strategies of Personal Computer Firms

	Startups	Diversifying entrants	χ^2-value
Entry 1972–1984			
Not entering with Intel x86 CPU but later migrating to Intel x86	33.7%* ($N = 86$)	58.7% ($N = 46$)	7.65[a]
Not entering with newest product technology but later expanding line to include a portfolio of the newest and most popular technologies	8.5% ($N = 94$)	13.0% ($N = 46$)	0.71
Entry 1985–1994			
Not entering with Intel x86 CPU but later migrating to Intel x86	50.0% ($N = 16$)	53.9% ($N = 13$)	0.04
Not entering with newest product technology but later expanding line to include a portfolio of the newest and most popular technologies	42.3% ($N = 265$)	28.0% ($N = 82$)	5.32[a]

*100 − 33.7 = 66.3% of the startups not entering with Intel x86 CPU never migrated to Intel x86. [a]Significant at 0.01 level (2-tail); [b]significant at 0.05 level (2-tail); [c]significant at 0.10 level (2-tail).

that began in 1983) established the PC-clone market by designing and producing a machine based on the 80386 CPU. A set of mutually exclusive dummy variables involving their product technology strategy and pre-entry experience was constructed to directly test for any differences between entrepreneurial startups and diversifying entrants.

The results in Table 3, Model 1 strongly support H1 and H2. The Test of Coefficient Equality indicates that the coefficient estimates of *Startup* and *Diversifying Entrant Entering With Intel x86* are statistically equivalent, but the coefficient estimates for *Startup* and *Diversifying Entrant Not Entering With Intel x86* are significantly different. Moreover, the positive and significant estimate for *Startup Not Entering With Intel x86* indicates that startups not entering with the technology standard have higher exit hazards than diversifying entrants not entering with the standard. We provide evidence for discriminant validity of this finding by demonstrating that these same results do not hold for later entrants in Model 2. Supported by the cross-tabulations in Table 4, we argue that this result is due to the firms' product strategies involving the emerging technology standard. Before 1985, 59% of the diversifying entrants not entering with the Intel x86 technology eventually migrated to the Intel x86 architecture, while only 34% of the startups did so (this difference is statistically significant at the 0.01 level). After 1984, not surprisingly the vast majority of firms entered with a product involving the Intel standard (of the 326 startups entering after 1984, 95% entered with a product using the Intel x86 CPU; of 98 diversifying entrants, 87% entered with the Intel x86 technology).

The results in Table 5, Model 2 support H4. The Test of Coefficient Equality indicates that the coefficient estimates of *Startup* and *Diversifying Entrant Not Entering With Newest Technology* are significantly different. The positive and significant estimate of *Diversifying Entrant Not Entering With Newest Technology* indicates that diversifying entrants not entering with the newest technology have higher exit hazards than startups not entering with the newest technology. We provide evidence of discriminate validity for this finding by showing that this same result does not hold for early entrants in Model 1.

As supported by the tabulations in Table 4, we argue that this result is due to firms' product technology strategies in the later stages of the industry

Table 5 Discrete Time Estimation Results of Personal Computer Firm Exit and the Conditioning Effects of Entry Time and Pre-Entry Experience: Testing H3 and H4

Variables	Model 1 (Entry 1974–1984)	Model 2 (Entry 1985–1994)
Startup Entering With Newest Technology	−0.021 (0.232)	0.120 (0.238)
Diversifying Entrant Entering With Newest Technology	−0.648[c] (0.348)	−0.836[c] (0.507)
Diversifying Entrant Not Entering With Newest Technology	−0.127 (0.229)	0.387[c] (0.244)
Test of coefficient equality (χ^2)		
H3: *Entering With Newest Tech* (*Startup* = *Diversifying Entrant*)	3.05[c]	2.94[c]
H4: *Not Entering With Newest Tech* (*Startup* = *Diversifying Entrant*)	0.31	2.52[c]
Controls		
Firm Age	0.039 (0.118)	0.492[c] (0.277)
Firm Age^2	−0.001 (0.006)	−0.022 (0.018)
Firm Age Before Entry	−0.011 (0.007)	0.001 (0.008)
Firm Size	−0.170[a] (0.050)	−0.313[a] (0.075)
Entry Time	0.171 (0.183)	0.201[a] (0.066)
Density	0.015[b] (0.007)	0.163[a] (0.057)
Density^2 ($\times 10^{-2}$)	−0.003[c] (0.002)	−0.036[a] (0.012)
Density at Founding	−0.010 (0.011)	0.001 (0.003)
Unobserved heterogeneity (σ)	0.001 (0.217)	0.897 (0.490)
Constant	−4.079[a] (0.881)	−24.227[a] (6.763)
Log-likelihood	−473.42	−749.40
χ^2 (df)	54.37[a] (11)	60.26[a] (11)
N	1,434	1,649

Notes. Standard errors are in parentheses. [a]Significant at 0.01 level (2-tail); [b]significant at 0.05 level (2-tail); [c]significant at 0.10 level (2-tail).

life cycle. After 1984, 42% of the entrepreneurial startups not entering with the newest technology eventually expanded their line to include a portfolio of products with new and old technologies, while only 28% of the diversifying entrants did so (this difference is statistically significant at the 0.01 level). We believe that this result is due to the different perspectives startups and diversifying entrants take toward the issue of product cannibalization. Being more concerned with the risks of cannibalization, diversifying entrants are more likely than startups to postpone the introduction of new products with the most advanced technology. Interestingly, the results in Table 5 suggest that the diversifying entrants in the personal computer industry that are willing to "eat their own lunch" by introducing products with the latest technology have lower mortality rates than startups (Nault and Vandenbosch 1996, McGrath 2001). Although this result is contrary to our H3 (at the 0.10 level), it does suggest that firms that are able to manage a portfolio of products across the successive technology generations that become available as an industry evolves have higher survival rates. Additional research is needed to refine our current H3.

7. Robustness Checks

Several robustness checks were undertaken to confirm the empirical results reported in the previous section. These analyses are briefly discussed here. First, other discrete-time survival formulations like the logistic hazard model gave very similar results to those presented in Tables 1, 2, 3, and 5. Second, we considered whether our main results are strongly influenced by the activities of a small number of key players in the personal computer industry. Discrete-time hazard models estimated without IBM, Apple, Dell, and HP (e.g., as in Bresnahan et al. 1997) were very similar to those already discussed and thus our conclusions remain unchanged. Third, we were able to confirm our results and conclusions when market share was the performance measure rather than firm survival. Random-effects panel regression models of market share that parallel the models in Tables 1, 2, 3, and 5 gave the same conclusions to those already discussed.

Finally, we considered the issue of firm entry selection as an explanation for our findings (e.g., diversifying entrants that are "worse" performers in general are likely to enter later simply because they are poor performers, and because they are weak performers they are also likely to choose product technology strategies poorly). While our data do not allow us to completely correct for potential entry selection from a comprehensive pool of potential entrants, we can examine whether there are any systematic firm characteristics related to *Entry Time* among the firms that did enter the personal computer industry. Dividing our sample by firm lifetime (firm exit year less firm entry year), estimation results of Cox proportional hazard models for type of firm pre-entry experience and *Firm Age Before Entry* are in Table 6. Among firms that failed quickly in this industry (i.e., "poor performers"), there is no difference in entry times for firms with prior technical and/or marketing experience, or the more experienced entrants that are older at entry. Thus, with the exception of diversifying entrants with "other experience," entry of poor performers seems to be spread across the time period of our study. Separate analyses excluding all firms with "other experience" does not significantly change any of our reported results. Among the more successful firms (i.e., firms with lifetimes > two years), firms with prior technical experience and those with greater experience tend to enter *later* rather than earlier, which is contrary to the selection hypothesis. Separate analyses excluding all firms with only technical experience gives results that are consistent with those already presented, and thus our major conclusions are unaffected.

Table 6 **Cox Proportional Hazard Estimation Results of Personal Computer Firm Entry Time**

Variables	Model 1 (Firm lifetime $\leq$ 2 years)	Model 2 (Firm lifetime > 2 years)
Only Technical Exp.	−0.076 (0.204)	0.594[a] (0.156)
Only Marketing Exp.	−0.228 (0.188)	−0.060 (0.317)
Technical & Marketing Exp.	−0.069 (0.412)	0.020 (0.247)
Other Exp.	0.878[a] (0.302)	−0.420 (0.379)
Firm Age Before Entry	−0.001 (0.006)	0.007[c] (0.004)
Log-likelihood	−1,060.32	−1,660.43
χ^2 (df)	11.59[b] (5)	26.03[a] (5)
N	229	336

Notes. Robust standard errors are in parentheses. [a]Significant at 0.01 level (2-tail); [b]significant at 0.05 level (2-tail); [c]significant at 0.10 level (2-tail).

8. Implications and Conclusions

We started with three questions that guided our research. What product technology strategies increase the survival chances of entrants into new, technologically dynamic industries? Does the effectiveness of these strategies differ by pre-entry experience? Does the effectiveness of these strategies differ by when firms enter a new industry? We find that successful product technology strategies in the personal computer industry involve migrating to the eventual technology standard and introducing products with the newest available technology. Moreover, we find that the effectiveness of these product strategies depends on who implements it (pre-entry experience) and when it is employed (entry timing). In particular, diversifying entrants are more likely than entrepreneurial startups to migrate to the technology standard when it becomes known, and consequently, they enjoy higher survival rates in the early years of this new industry. For later entrants, however, startups are more likely than diversifying entrants to expand their product line to include the newest technology, and thus they tend to have higher survival rates in the later years. Our findings highlight that it is important to study what firms do after they enter a new industry to more completely understand their ultimate performance.

Our results also suggest that a "dominance by birthright" (Klepper and Simons 2000) does not exist in the personal computer industry. In other words, early entering diversifying entrants do not always have a survival advantage over other entrants. As already noted, our finding that firm survival is significantly related to firms' product technology strategies after they enter a new industry indicates the important role of post-entry activities. In addition, our estimates of the corporate demographic effects in the personal computer industry suggest that the survival rates of later entrants can surpass those of the early entering diversifying entrants. Although firm size tempers the effects, the relative magnitudes of the coefficient estimates for firm age (liability of obsolescence) and entry time indicate that the exit hazards of young, later entrants can be lower than those of old, early entrants (under some conditions). These results support our general approach of studying the strategies of later entrants as well as early entrants.

Our study has some limitations that open avenues for future research. In particular, studies of other industries need to be undertaken before our results for the personal computer industry can be generalized. Although new data sets may be needed, such efforts will move us closer to a more complete theory of firm behavior and survival dynamics where we better understand the contingency effects of industry conditions (e.g., technology dynamism, ease of entry/exit, market scope). Following prior research, we used a single dummy variable for pre-entry experience to examine effects of firm heterogeneity at time of entry; future research could include time-varying and continuous measures of experience within the focal industry as well as in other (diversified) industries. Future research could also further explore firm heterogeneity in implementing common product strategies (e.g., product line length, mix of advanced technology and more popular products), as well as the timing of implementation (e.g., is it advantageous to anticipate the technology standard?). Importantly, like most research in this stream, we lack appropriate data to directly study the entry selection question; future research is clearly needed to endogenously model the firm's entry and exit decisions (e.g., as in Macieira 2006). Clearly, other dimensions of firms' product strategies need to be studied in future research because some long-lived firms did not follow the strategies we find as being strongly related to survival (e.g., Apple was a startup firm that never offered the Intel x86 technology), and contrary to our H3, diversifying entrants entering with the latest technology have higher survival rates than startups.

While our study focuses on pre-entry experience embodied in organizations, additional research is also needed on how pre-entry experience possessed by managerial teams may affect firm performance. Recent research emphasizes the spin-out phenomenon (i.e., entrepreneurial startups with pre-entry experience due to the prior employment of its founders with an incumbent firm; e.g., Agarwal et al. 2004). Spin-outs seem to have superior performance relative to all other entrants. Importantly, experienced managers of entrepreneurial startups may mitigate the advantage of diversifying entrants. While we lack systematic data on founding teams of entrepreneurial startups, the personal computer industry includes cases of successful spin-out firms such as Compaq and Gateway, along with several entrepreneurial startups that did not benefit from pre-entry experience through founder affiliation who also performed well (e.g., Apple, Dell). Extending our study in this direction should lead to an even greater understanding of the role of product strategies in technologically dynamic industries.

In summary, prior research emphasizes that pre-entry experience and entry timing are important determinants of a firm's success in a new industry. The contribution of our paper is to further refine these relationships by examining what firms do *after* they enter the industry in terms of selecting their product technology strategies. By examining the conditioning effects of prior experience and entry timing on the relationship between product strategies and survival, we provide a more strategic explanation for the phenomena, as opposed to the prior literature that has focused on capabilities gained through experience. We encourage future research to adjudicate when each of these perspectives may be more important.

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Appendix. Descriptive Statistics and Correlations

Variables	μ	σ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Exit	0.16	0.37	1																	
2. *Diversifying Entrant*	0.31	0.46	0.06	1																
3. *Entry Time*	11.25	4.32	0.14	−0.25	1															
4. *Firm Size*	3.15	15.11	−0.09	0.13	−0.20	1														
5. *Firm Age*	4.40	3.39	−0.04	0.22	−0.46	0.36	1													
6. *Firm Age Before Entry*	6.50	16.57	−0.08	0.58	−0.21	0.16	0.21	1												
7. *Density*	211.05	75.68	0.09	−0.09	0.63	0.05	0.23	−0.06	1											
8. *Density at Founding*	152.46	91.88	0.13	−0.26	0.97	−0.18	−0.43	−0.23	0.63	1										
9. *Ever Offer Intel x86*	0.88	0.33	−0.11	0.09	0.32	−0.02	0.09	0.08	0.44	0.34	1									
10. *Cumulative Time in Market Without Intel x86*	0.23	0.96	−0.08	0.15	−0.27	0.05	0.07	0.04	−0.24	−0.27	0.09	1								
11. *Ever Offer Newest Product Technology*	0.83	0.37	−0.23	0.04	0.08	0.08	0.21	0.03	0.21	0.12	0.43	0.04	1							
12. *Cumulative Number of Newest Product Technology Generations Ever Offered*	0.80	0.82	−0.07	0.07	−0.16	0.37	0.63	0.08	0.17	−0.11	0.13	−0.07	0.38	1						
13. *Startup Not Entering With Intel x86*	0.19	0.40	0.03	−0.35	−0.45	−0.03	0.04	−0.20	−0.46	−0.46	−0.53	−0.25	−0.25	−0.11	1					
14. *Startup Entering With Intel x86*	0.49	0.50	0.04	−0.66	0.59	−0.10	−0.24	−0.38	0.45	0.45	0.34	−0.23	0.16	0.02	−0.48	1				
15. *Diversifying Entrant Entering With Intel x86*	0.15	0.36	0.02	0.60	0.18	−0.03	−0.06	0.24	0.14	0.14	0.15	−0.10	0.01	0.01	0.21	−0.40	1			
16. *Diversifying Entrant Not Entering With Newest Technology*	0.20	0.40	0.00	0.73	−0.02	−0.00	0.05	0.41	0.03	−0.07	0.04	0.07	−0.06	−0.15	−0.25	0.40	−0.52	1		
17. *Startup Entering With Newest Technology*	0.16	0.36	0.00	−0.30	−0.14	0.00	0.01	−0.18	−0.18	−0.10	−0.15	−0.02	0.17	0.27	0.25	0.08	−0.18	−0.22	1	
18. *Diversifying Entrant Entering With Newest Technology*	0.11	0.31	−0.09	0.53	−0.33	0.19	0.26	0.33	−0.16	−0.29	0.08	0.14	0.14	0.29	−0.18	−0.35	0.20	−0.19	−0.16	1

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