Qi Wang, Yubo Chen, & Jinhong Xie

Survival in Markets with Network Effects: Product Compatibility and Order-of-Entry Effects

This article proposes a new conceptual framework in which the impact of network effects (NE) on a pioneer's survival advantage compared with its early followers can be positive or negative depending on two important but previously ignored market characteristics: (1) cross-generation product compatibility and (2) within-generation product compatibility. The authors empirically test the theoretical predictions using data from 45 NE markets. They show that these two types of compatibility affect the pioneer's survival advantage in opposite directions and that such directions are reversed when NE changes from extremely strong to extremely weak. Specifically, in markets with strong NE, cross-generation incompatibility harms but within-generation incompatibility favors the pioneer's survival advantage. Consequently, pioneers are likely to enjoy a survival advantage when their product is cross-generation compatible but within-generation incompatible. However, in markets with weak NE, pioneer survival advantage is likely to occur under opposite conditions (i.e., cross-generation incompatible but within-generation compatible). The policy analysis further suggests that the best survival condition for pioneers often turns out to be the worst for followers in these markets.

Keywords: network effects, product compatibility, order-of-entry effects, survival analysis

Network effects (NE) (also called network externalities) refer to the market phenomenon in which the value of a product or service to consumers depends on the number of users of that product or service (for a detailed discussion, see Katz and Shapiro 1985, 1994). With rapid advances in information technology and the digital revolution, NE have become an important characteristic of an increasing number of industries and product/service categories (e.g., computers, communications, consumer electronics, software, financial exchanges, online auctions, home networking, social networking Web sites).

Markets with NE often exhibit significantly high market uncertainty and innovation risk (e.g., Chakravarti and Xie 2006). For example, unlike traditional markets, consumer adoption utility in the NE markets depends not only on product quality but also on the size of the user base of the underlying technology (Katz and Shapiro 1994). This "installed-base effect" creates a unique "start-up" difficulty for innovating firms because the new product may offer little value to early adopters at the time of product launch because of its limited user base (Katz and Shapiro 1986). Furthermore, standards competition is common in the presence of NE (Shapiro and Varian 1998). During the past two decades, many fierce standards battles have occurred between incompatible technologies (e.g., Betamax versus VHS VCR player, Microsoft Windows versus Apple Macintosh operation system, Blu-ray versus high-definition DVD player). Brutal standards battles not only reduce competing firms' profits but also make a "winner-take-all" market outcome more likely to occur (Schilling 2002; Shapiro and Varian 1998). These unique characteristics make survival a primary performance concern for firms competing in markets with NE (Srinivasan, Lilien, and Rangaswamy 2004).

An increasing number of researchers have addressed the implications of NE on emerging issues such as pricing (e.g., Xie and Sirbu 1995), product line (Sun, Xie, and Cao 2004), software piracy (Haruvy, Mahajan, and Prasad 2004), cross-market NE (Chen and Xie 2007), indirect NE (Stremersch et al. 2007), and new product success (Tellis, Yin, and Niraj 2009). Research has also provided empirical evidence of NE in various industries, including high-definition televisions (Gupta, Jain, and Sawhney 1999), video games (Shankar and Bayus 2003), CD players (Basu, Mazumdar, and Raj 2003), and personal digital assistants (Nair, Chintagunta, and Dubé 2004). However, few studies have been undertaken on firms' survival in NE markets.

The survival literature suggests that firms' market entry order plays an important role in their ability to survive (e.g., Golder and Tellis 1993). Various studies have provided empirical evidence for pioneer survival (dis)advantage under different conditions (e.g., Lilien and Yoon 1990; Min, Kalwani, and Robinson 2006; Robinson and Min 2002).

Qi Wang is Assistant Professor of Marketing, State University of New York at Binghamton (e-mail: qiwang@binghamton.edu). Yubo Chen is Assistant Professor of Marketing, Eller College of Management, University of Arizona (e-mail: yubochen@eller.arizona.edu). Jinhong Xie is Etheridge Professor of International Business and Professor of Marketing, Warrington College of Business Administration, University of Florida (e-mail: jinhong.xie@warrington.ufl.edu).

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Because the installed-base effect exhibited in markets with NE implies both a higher first-mover risk and a higher first-mover benefit than traditional markets, the order-of-entry effect on survival in NE markets can be even more complicated and critical. Despite the importance of survival in NE markets, however, pioneer survival (dis)advantage in such markets has received scant academic attention. Recently, Srinivasan, Lilien, and Rangaswamy (2004) took the first step toward empirically investigating firm survival in markets with NE using data from 45 product categories. Their work provides the first empirical evidence of the negative impact of NE on the survival duration of a pioneer's product. However, their research focuses on pioneer products only and does not directly address the order-of-entry effect.

The current research investigates the order-of-entry effect on survival in NE markets. We propose that pioneers' survival (dis)advantage, compared with early followers, is contingent on product (in)compatibility, which is an essential product characteristic in these markets (e.g., Chakravarti and Xie 2006; Katz and Shapiro 1985; Xie and Sirbu 1995). Specifically, we consider two fundamentally different types of incompatibility: (1) cross-generation incompatibility (i.e., if the underlying product is incompatible with previous-generation products) and (2) within-generation incompatibility (i.e., if the product is incompatible with other products in the same generation). For example, current-generation DVD players are cross-generation incompatible with previous-generation VCR players but are within-generation compatible with each other.

We begin by developing a theoretical framework on how a pioneer's survival (dis)advantage is jointly affected by NE and by the two types of incompatibility. We then empirically test the theoretical hypotheses using data from 45 markets with different degrees of NE. The results reveal some intriguing systematic patterns of contingency. First, we find a significant interaction effect between NE and the two types of incompatibility. In markets with weak NE, the two types of product incompatibility affect the pioneer's survival advantage in opposite directions: Cross-generation incompatibility strengthens the pioneer's survival advantage, but within-generation incompatibility weakens it. However, as NE increase, the impact of both types of incompatibility becomes weaker in their original directions, and eventually their directions are reversed; that is, when NE are strong, cross-generation incompatibility becomes harmful to the pioneer's survival advantage, but within-generation incompatibility becomes helpful. Second, although the data reveal a lower average survival duration faced by pioneers than by early followers in markets with NE, we find some conditions under which pioneers can experience a survival advantage relative to the early followers. It is striking that (1) such a pioneer survival advantage can occur in markets with both strong and weak NE and (2) the two cases (strong or weak NE) require opposite compatibility conditions. Specifically, we find that pioneers have longer survival duration than early followers in markets with strong NE if the pioneer is cross-generation compatible but not within-generation compatible and in markets with weak NE if the pioneer is within-generation compatible but not cross-generation compatible. These findings provide important insights for both theory and practice.

We organize the remainder of this article as follows: In the next section, we present the conceptual framework and develop the hypotheses. We then describe the data and estimation method and present the empirical results. Finally, we discuss the contributions of this research and the managerial implications of the results.

Conceptual Development

In this section, we first define product (in)compatibility and then develop six theoretical hypotheses. The first four hypotheses focus on the impacts of two types of product incompatibility (cross- and within-generation) on pioneer survival advantage, and the last two hypotheses focus on the conditions under which pioneers are more likely to survive longer than early followers in markets with NE.

Product Compatibility

Product compatibility is a fundamental issue in NE markets (e.g., Farrell and Saloner 1985; Katz and Shapiro 1985; Xie and Sirbu 1995), though the technical definition of "compatibility" may be product specific. To provide a more general definition of compatibility that can apply to different types of products, we adopt the term "interchangeability," which has been used to discuss standardization in the literature (e.g., Kindleberger 1983). Specifically, we call the underlying products "compatible" if they are able to achieve interchangeability. For products with direct NE (e.g., communications networks, modems, facsimile [fax] machines, videoconferencing equipment), interchangeability refers to the interconnection between different networks. For products with indirect NE (e.g., hardware/software systems), interchangeability of products means that the components of one system can work with those of other systems (Katz and Shapiro 1994). For example, CD players from Sony and Philips are compatible because both players can play the same CDs. However, ink-jet (and laser) printers from Hewlett-Packard and Canon are not compatible because they only work with their respective cartridges. We believe that product compatibility is a potentially crucial survival factor for firms competing in NE markets because with incompatible products, firms tend to engage in standards wars. Such a specific form of competition can significantly increase market uncertainty for all related players, such as manufacturers and producers of complementary products (Srinivasan, Lilien, and Rangaswamy 2006). Furthermore, standards competition affects consumer behavior because it imposes additional adoption risks (Chakravarti and Xie 2006). For example, adopting a product that uses a losing standard incurs significant costs for consumers. Therefore, firm competition and survival rates among different market players differ greatly as a result of product incompatibility.

The extant literature has considered two specific types of product incompatibility: (1) cross-generation (e.g., Choi 1994; Dhebar 1995; Postrel 1990) and (2) within-generation (e.g., Farrell and Saloner 1985; Xie and Sirbu 1995). Cross-generation incompatibility occurs between products in different generations (e.g., the fax machine versus the telegraph transmitter, DVD players versus VCRs). Within-generation incompatibility applies to products developed within the same generation (e.g., VHS versus Betamax VCR players). Although the literature has examined the impact of product compatibility on some important firm strategies, such as pricing and advertising (e.g., Chakravarti and Xie 2006; Farrell and Saloner 1985; Xie and Sirbu 1995), or consumer behavior (Chakravarti and Xie 2006), the impact of product compatibility on firms' survival ability has not been investigated. Furthermore, it is important to understand whether these two types of incompatibility influence product survival differently. In the following discussion, we examine how each type of product incompatibility might influence pioneer survival (dis)advantage and how these impacts might vary with the strength of NE.

Impact of Cross-Generation Incompatibility

When products are incompatible with those of a previous generation, this incompatibility creates two opposite impacts on the order-of-entry effect and, in turn, on pioneer advantage in survival duration: a positive "consumer preference" effect and a negative "market uncertainty" effect. First, a positive consumer preference effect occurs because cross-generation product incompatibility strengthens a pioneer's ability to enjoy the first-mover advantage on consumer preference formation. The first-mover advantage literature shows that one major source of pioneering advantage arises from consumer preference formation (Carpenter and Nakamoto 1989; Kerin, Varadarajan, and Peterson 1992). Carpenter and Nakamoto (1989) argue that when a new category is introduced and consumer category preference is not well defined, consumers tend to form their preferences in line with the market pioneer's product and consider its product the category stereotype. When later entrants arrive, they are compared with the pioneer, the market stereotype, and thus may be perceived disadvantageously.

In NE markets, introducing cross-generation compatible products limits the pioneer's ability to redefine consumer preferences. In contrast, it seems reasonable that cross-generation incompatibility strengthens such a pioneer advantage because cross-generation incompatible products usually feature different technologies from those of the previous generation, which implies a significant product differentiation between the new-generation product and that of the existing generation. For example, the DVD player was created as a result of the development of digital technology and was not compatible with its precursor, the VCR, which was based on analog technology. When the DVD player was introduced, consumers needed to develop totally new preferences. The significant product differentiation due to cross-generation incompatibility provides an opportunity for the pioneer to redefine consumer preferences (Dhebar 1995).

Second, a negative market uncertainty effect occurs because cross-generation product incompatibility intensifies the pioneer's disadvantage relative to that of later entrants on the degree of uncertainty encountered. In general, when a new-generation product category is developed, the first mover often faces more uncertainties than later entrants because it enters the market with less information about the market's response to the new-generation product. The survival literature (e.g., Hannan and Freeman 1984) suggests that to have high survival likelihood, a firm must demonstrate its reliability to its customers, its investors, and its partners. However, when a new-generation product is incompatible with that of the previous generation, such demonstration is significantly more difficult for pioneers than for later entrants because all important parties (e.g., consumers, investors, complementary-product firms, retailers) face considerable risk by supporting the innovation. This high risk can motivate the parties to delay their adoption of or support for the new-generation product until enough evidence exists to raise their confidence level in relation to the success of the innovation. As a result, a pioneer can fail simply because its product is the first available of the new generation and it has no installed-base support from the existing-generation product.

Furthermore, it is important to emphasize that the magnitude of such a negative market uncertainty effect of cross-generation incompatibility on pioneers' survival advantage increases with the strength of NE. This increase occurs because the stronger the NE, the greater the likelihood is for consumers, investors, and downstream firms to delay their investment in the new-generation product, thus leading to the greater survival disadvantage of being the market pioneer.

The overall impact of cross-generation product incompatibility on pioneers' survival advantage is determined by the net impact of these two opposite effects. Note that the positive consumer preference effect does not vary with NE. However, the negative market uncertainty effect intensifies when NE become stronger. Therefore, we expect that, in general, the impact of cross-generation product incompatibility on pioneering survival advantage (the order-of-entry effect) decreases with the strength of NE. Formally,

> H_1: The impact of cross-generation incompatibility on pioneer survival advantage decreases with the strength of NE.

The first hypothesis specifies how the impact of cross-generation incompatibility on pioneer survival advantage changes when NE become stronger. We now consider the overall effect of cross-generation incompatibility on pioneer survival advantage in markets with extremely weak and extremely strong NE. In markets with extremely weak NE, the positive consumer preference effect may dominate the negative market uncertainty effect. Thus, the net effect associated with cross-generation incompatibility on pioneering advantage would be positive. As the NE increase from extremely weak to extremely strong, cross-generation incompatibility significantly intensifies the uncertainties that pioneers face compared with those that later entrants face, and the negative market uncertainty effect could dominate the positive consumer preference effect. As a result, the cross-generation incompatibility could negatively affect pioneering survival advantage in markets with extremely strong NE.

A good example is the television market, which exhibits strong indirect NE because the value of a television set (hardware) for a consumer strongly depends on the availability of television programming (software) in the market. CBS invented the mechanical color television system in 1940 and was the first to launch color television to the American general public in 1950 (Fisher and Fisher 1997; Shapiro and Varian 1999). The CBS color television technology was cross-generation incompatible with black-and-white (B&W) television: Existing B&W television sets could not pick up the color broadcasts from CBS stations, nor could the CBS color sets receive the B&W programs. This cross-generation incompatibility created a huge market uncertainty regarding the public acceptance of the new-generation television sets. Millions of B&W television set owners were unwilling to invest $100 for the CBS color sets, and advertisers were unwilling to sponsor broadcasts that were seen by few people. Thus, as a result of the negative uncertainty effect of cross-generation compatibility, CBS's color television technology soon failed in the market.

This discussion leads to the following hypothesis on the effect of cross-generation incompatibility in markets with extremely weak and extremely strong NE:

> H_2: The impact of cross-generation incompatibility on pioneer survival advantage is (a) positive in markets with extremely weak NE and (b) negative in markets with extremely strong NE.

Impact of Within-Generation Incompatibility

When products within a generation are incompatible, this incompatibility also creates two opposite impacts on pioneer advantage in survival duration: a negative "product-differentiation" effect and a positive "installed-base" effect. On the one hand, within-generation incompatibility can lead to a negative product-differentiation effect on pioneering advantage because, as is suggested in the order-of-entry literature, a later entry can outperform pioneers by introducing a distinctive product (Carpenter and Nakamoto 1989). In markets with NE, within-generation incompatibility enables the later entrant to achieve a higher level of product differentiation between its product and that of the pioneer (e.g., Besen and Farrell 1994; Kim 2002). It also makes it more difficult for consumers to directly compare a later entrant's product with that of the pioneer. Thus, incompatibility helps a later entrant distinguish its product from existing products, meet consumers' demand heterogeneity, and reduce long-term price competition (Katz and Shapiro 1986, 1994).

On the other hand, within-generation incompatibility can create a positive installed-base effect for pioneers relative to their early followers because within-generation incompatibility imposes a start-up difficulty for the later entrant. As the first-mover advantage literature suggests, market pioneers can benefit from preempting the market and setting a high entry barrier for followers (e.g., Lieberman and Montgomery 1988). In markets with NE, the most important entry barrier for followers is the installed-user base. With within-generation incompatibility, a later entrant's product can only derive benefits from its own installed base rather than the combined installed bases of the pioneer's. Moreover, within-generation incompatibility creates a huge switching cost to consumers of existing products (Farrell and Klemperer 2007). IBM's decision not to introduce its 4-inch floppy disk drive (FDD) provides an illustrative example of the positive installed-base effect enjoyed by the pioneer, Sony's 3.5-inch FDD. As Porter (1983) reports, although IBM initially announced a plan to introduce a 4-inch FDD, it eventually gave up such a plan because the 3.5-inch FDD was increasingly adopted by computer system manufacturers and end consumers. The installed base of the 3.5-inch FDD thus erected an entry barrier to IBM's 4-inch FDD and deterred its entry, providing a positive installed-base effect to the pioneer, Sony.

Thus, the overall impact of within-generation incompatibility depends on the magnitude of these two opposing influences. Note that the negative impact of within-generation incompatibility arising from the followers' product-differentiation effect does not vary with NE. However, the positive impact of within-generation incompatibility arising from the pioneer's installed-base advantage is more significant in markets with stronger NE. As a result, we expect that, in general, the impact of within-generation product incompatibility on pioneer advantage (the order-of-entry effect) increases with the strength of NE. Formally,

> H_3: The impact of within-generation incompatibility on pioneer survival advantage increases with the strength of NE.

In markets with extremely weak NE (zero in the extreme case), the start-up problem for market followers to establish an installed user base is negligible. As a result, the negative impact of within-generation incompatibility from high differentiation for pioneers can dominate the positive installed-base impact. Thus, the net effect associated with within-generation incompatibility on pioneering advantage would be negative. As NE increase from extremely weak to extremely strong, within-generation incompatibility affects pioneering survival advantage positively because it imposes significant difficulties on followers in establishing their installed bases. Thus, for market pioneers, the positive installed-base effect of within-generation incompatibility can dominate the negative product-differentiation effect. For example, as a type of data communication network, the local area network (LAN) has an extremely high NE. As the market pioneer, Xerox developed the Ethernet standard in the late 1970s to send data at a high speed among the laser printers within a LAN. Several years later, IBM launched an incompatible standard, Token Ring, into the market. Although its performance was believed to be superior to the Ethernet standard, the latter had such a large installed base that it could not be overtaken. Eventually, Token Ring failed in the market, and Ethernet became the winning LAN standard (Shapiro and Varian 1998).

This discussion leads to the following hypothesis on the effect of within-generation incompatibility in markets with extremely weak and extremely strong NE:

> H_4: The impact of within-generation incompatibility on pioneer survival advantage is (a) negative in markets with extremely weak NE and (b) positive in markets with extremely strong NE.

Overall Order-of-Entry Effects

We now discuss the conditions under which pioneers are likely to have a survival (dis)advantage in markets. The previous discussion suggests that in markets with extremely weak NE, cross-generation incompatibility has a positive impact on pioneers' survival advantage, whereas within-generation incompatibility has a negative impact. As a result, when products are cross-generation compatible but within-generation incompatible, pioneers will be at a disadvantage compared with early followers. In contrast, when products are cross-generation incompatible but within-generation compatible, pioneers will be more likely to have an advantage in survival duration over the early followers. As NE increase from extremely weak to extremely strong, when products are cross-generation compatible but within-generation incompatible, pioneers can gain a strong survival advantage; when products are cross-generation incompatible but within-generation compatible, however, pioneers are at a disadvantage compared with early followers.

Thus, we formalize the following hypotheses on the overall order-of-entry effects:

H_5: When products are cross-generation compatible but within-generation incompatible, the pioneer survival advantage (a) increases with the strength of NE; (b) is negative in markets with extremely weak NE, such that the pioneer has a survival disadvantage; and (c) is positive in markets with extremely strong NE, such that the pioneer has a survival advantage.

H_6: When products are cross-generation incompatible but within-generation compatible, the pioneer survival advantage (a) decreases with the strength of NE; (b) is positive in markets with extremely weak NE, such that the pioneer has a survival advantage; and (c) is negative in markets with extremely strong NE, such that the pioneer has a survival disadvantage.

Note that when products are both cross-generation and within-generation compatible or incompatible, the two types of (in)compatibility have opposite impacts on pioneer survival advantage. Therefore, the overall order-of-entry effects become less significant because of such opposing impacts. The directions of the overall effects are ambiguous, depending on the magnitude of the two types of product (in)compatibility. Thus, there is no clear theoretical prediction in these cases, and the result is purely empirical.

In summary, our conceptual development suggests that the overall order-of-entry effect is contingent on the specific type of product compatibility and the strength of NE. Pioneers can have a survival advantage in markets with both strong and weak NE; however, the two cases require opposite compatibility conditions. We summarize the conceptual framework in Figure 1 and the theoretical hypotheses in Table 1.

FIGURE 1
Conceptual Framework for Hypothesis Development

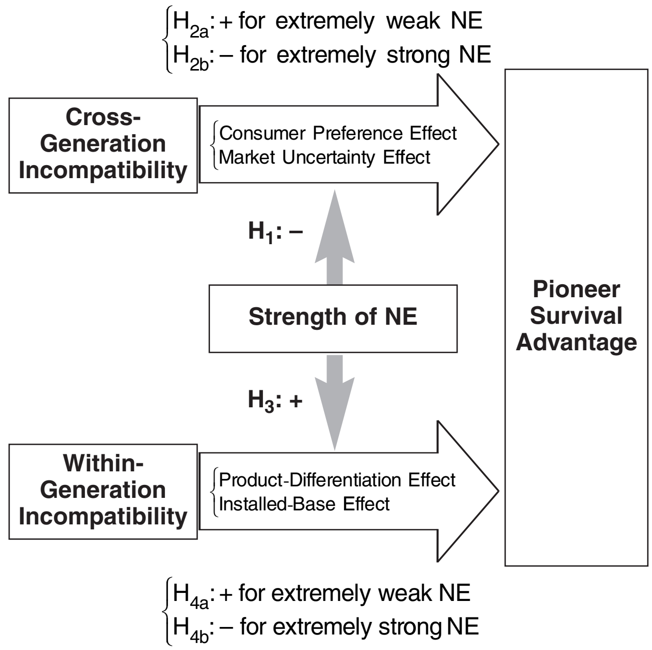


TABLE 1
Summary of Theoretical Hypotheses

A: Impacts of Product Compatibility on Pioneer Survival Advantage			
Cross-Generation Incompatibility		**Within-Generation Incompatability**	
Decrease with NE (H_1)		**Increase with NE (H_3)**	
Markets with extremely weak NE	Positive (H_{2a})	Markets with extremely weak NE	Negative (H_{4a})
Markets with extremely strong NE	Negative (H_{2b})	Markets with extremely strong NE	Positive (H_{4b})
B: Overall Order-of-Entry Effects on Product Survival Duration			
Cross-Generation Compatible/ Within-Generation Incompatible		**Cross-Generation Incompatible/ Within-Generation Compatible**	
Increase with NE (H_{5a})		**Decrease with NE (H_{6a})**	
Markets with extremely weak NE	Negative (H_{5b}) (pioneer disadvantage)	Markets with extremely weak NE	Positive (H_{6b}) (pioneer advantage)
Markets with extremely strong NE	Positive (H_{5c}) (pioneer advantage)	Markets with extremely strong NE	Negative (H_{6c}) (pioneer disadvantage)

Methods

Data and Variables

Srinivasan, Lilien, and Rangaswamy (2004) examine 45 categories affected by NE. Using the historical method (e.g., Golder and Tellis 1993; Sood and Tellis 2005), they identify the pioneer in each selected category from 1950 to 2001. These products range from computer hardware (e.g., mainframe computers, notebook computers, workstations), computer software (e.g., antivirus, database, desktop publishing), and consumer electronics (e.g., home VCRs, DVD players, televisions) to telecommunication equipment (e.g., cordless telephones, fax machines, wireless telephones) and office supplies (e.g., photocopiers, scanners, printers). Our empirical analysis focuses on the same 45 categories. We collect information not only on the pioneer but also on early followers in each selected category from 1950 to 2007.

First, we independently identified pioneers in these 45 product categories. In 42 of the 45 categories, the pioneers we identified are consistent with those in Srinivasan, Lilien, and Rangaswamy's (2004) study.[1] Such a high degree of result consistency suggests strong method validity. Second, using the pioneer in each category as the starting point, we traced forward, on a yearly basis, the news archives, articles published in scholarly journals, company histories, and online databases until we identified the early followers. Following Robinson and Min (2002), when multiple entrants were identified in the same year, we included them all in the database as early followers. Overall, the data set includes 45 pioneers and 55 early followers in 45 categories from 1950 to 2007. We offer a detailed description of market pioneers and early followers in all markets in Web Appendix A (http://www.marketingpower.com/jmjuly10). Next, we define the variables used in the empirical examination.

Survival duration and order of entry. We determined survival durations for pioneers and early followers by the length of time from year of entry to year of exit. Note that Srinivasan, Lilien, and Rangaswamy's (2004) study data collection ends in 2001. For pioneers reported under "exit" in their study, we used that measure of survival duration. For pioneers reported under "survival" in their study, however, we continued to identify their survival status until 2007 (i.e., the end point of the data collection). For the early followers, the starting point is 2007. We then traced backward, on a yearly basis, the news archives, articles published in scholarly journals, company histories, and online databases until we identified each firm's exit year. If a firm was still in the market by 2007, its survival duration constituted the length of time from the year it entered a market to 2007 and is right censored. Overall, among the 45 pioneers and 55 early followers we identified, 18 pioneers and 42 early followers were still in the market in 2007. We used a variable, PIONEER, to measure the order-of-entry effect (PIONEER = 1 for market pioneers, and PIONEER = 0 otherwise).

Product incompatibility. We first conducted extensive research and consulted experts (e.g., engineering professors) on information technology and consumer electronics to identify technical issues of compatibility for each product category. For example, for telecommunications networks (e.g., telephone and cell phone service networks) and office supplies (e.g., modems, fax machines), which are subject to direct NE, compatibility exists when subscribers to one network can communicate or interconnect with another network. For computer hardware and software (e.g., mainframes, notebooks, personal computers, workstations, software), for which indirect NE arise, compatibility exists when two units of hardware can use identical software. For consumer electronics (e.g., televisions, video game consoles, VCRs, CD players, DVD players), for which indirect NE can also occur, products are considered compatible if a complementary good (e.g., television broadcasts, game cartridges, videotapes, CDs, DVDs) can be used by different brands of the same product. For consumer appliances (e.g., toothbrushes, processors) with indirect NE, compatibility implies that a key component of one product can be used interchangeably with other products.

We then used the historical method to determine the two types of (in)compatibility for each firm's product at the time of introduction. We used two dummy variables, CGIC and WGIC, to denote cross-generation and within-generation incompatibility, respectively. Specifically, if a product was incompatible with its previous generation when it was introduced, then CGIC = 1; otherwise, CGIC = 0.[2] We adopted the same previous-generation product that Srinivasan, Lilien, and Rangaswamy (2004) use for each of the 45 product categories. Similarly, if a product was incompatible with other products in its generation when it was introduced, then WGIC = 1; otherwise, WGIC = 0. Of the 45 pioneers' products, 33 were cross-generation incompatible, and 25 were within-generation incompatible. Of the 55 early followers' products, 42 were cross-generation incompatible, and 28 were within-generation incompatible.[3] Table 2 reports the number of products with the two types of incompatibility for pioneers and early followers.

NE measure. We adopted the same measure of NE that Srinivasan, Lilien, and Rangaswamy (2004) use. Specifically, they measure the NE of the pioneer in each of the 45 categories using the sum of two ratings provided by nine academic raters: degree of direct NE and degree of indirect NE. We used the same measure of NE for the pioneer and its followers in the same category. Therefore, as in Srinivasan, Lilien, and Rangaswamy's study, the NE measured in the data set vary from 3.4 (weakest) to 12.1 (strongest).

[1]The three inconsistent cases are color television, computer-aided design software, and camcorders, for which we found earlier entrants than the pioneers identified by Srinivasan, Lilien and Rangaswamy (2004).

[2]For six product categories without previous generations, we consider these categories conceptually the same as cross-generation incompatible and code CGIC as 1.

[3]Because there could be more than one early follower (i.e., several followers enter in the same year) for a pioneer, the number of incompatible products is higher for followers than for pioneers.

TABLE 2
Product Compatibility Distribution

	Within-Generation Pioneers (N = 45)		Within-Generation Early Followers (N = 55)	
	Incompatible (WGIC)	Compatible (WGC)	Incompatible (WGIC)	Compatible (WGC)
Cross-Generation				
Incompatible (CGIC)	20	13	22	20
Compatible (CGC)	5	7	6	7

Control variables. We first collected all control variables in Srinivasan, Lilien, and Rangaswamy (2004) by following their methodologies. Specifically, to obtain the radicalness measurement for each product (RDC), we asked 18 master's degree students in engineering to rate each product category in two dimensions (each with a scale from 1 to 9): (1) whether a new product incorporates a substantially different core technology relative to the previous-generation product, and (2) whether a new product provides substantially greater customer benefits relative to the previous generation. We then measured the radicalness of a product category by adding together the ratings from these two dimensions. To facilitate the evaluation, we provided students with descriptions of each product category, such as the time of product introduction and the basic features and functions offered at that time.[4] To denote the incumbency status of a firm, we define a dummy variable INCUMB, such that INCUMB = 1 when the firm produces a product that belonged to the previous generation and 0 otherwise. For the firm size variable, if a firm employed at least 100 people at the time of entry, a dummy variable Size = 1; otherwise, Size = 0. We used a categorical technology intensity variable HTECH to classify product categories as high- or low-technology-intensive products according to the percentage of the number of research-and-development (R&D) employees relative to the total number of employees of the firms within a product category at the three-digit Standard Industrial Classification level.[5]

Because the data include not only pioneers but also followers, following Robinson and Min (2002), we include two additional control variables related to firm entry time: (1) lead time, defined as the number of lead years of a pioneer over its early followers, and (2) delay time, defined as the number of years the entry of an early follower was delayed after the pioneer's entry. The average lead time for the 45 pioneers is 4.82 years, and the average delay time for the 55 early followers is 3.13 years. (Note that the average lead time for the pioneers is different from the average delay time for early followers because of their different sample sizes.) We used the natural logarithm of the lead time and delay time in the estimation (Robinson and Min 2002). We also controlled for the effect of product age by adding the natural logarithm of the product introduction year in the estimation. We summarize the definitions of all variables in Table 3.

Model

We use the accelerated failure time (AFT) model (see Cox and Oakes 1984; Kalbfleisch and Prentice 1980) to estimate the impacts of the two types of incompatibility on survival durations in markets with NE. Specifically, we define the survival time as a function of two types of incompatibility and a set of control variables:

$$
\begin{aligned}
(1)\quad \mathrm{Lnt_i} = {} & \beta_0 + \beta_1\mathrm{PIONEER_i} + \beta_2\mathrm{CGIC_i} + \beta_3\mathrm{WGIC_i} \\
& + \beta_4\mathrm{NE_i} + \beta_5\mathrm{NE_i} \times \mathrm{CGIC_i} + \beta_6\mathrm{NE_i} \times \mathrm{WGIC_i} \\
& + \beta_7\mathrm{NE_i} \times \mathrm{PIONEER_i} + \beta_8\mathrm{CGIC_i} \times \mathrm{PIONEER_i} \\
& + \beta_9\mathrm{NE_i} \times \mathrm{CGIC_i} \times \mathrm{PIONEER_i} \\
& + \beta_{10}\mathrm{WGIC_i} \times \mathrm{PIONEER_i} \\
& + \beta_{11}\mathrm{NE_i} \times \mathrm{WGIC_i} \times \mathrm{PIONEER_i} \\
& + \beta_{12-19}\mathrm{CONTROL} + \sigma\varepsilon_i,
\end{aligned}
$$

where t_i denotes the survival duration of firm i. To examine the joint impacts of product compatibility and NE on pioneer survival advantage (H_1 and H_3), we need to test the coefficients of the three-way interaction terms of NE × CGIC × PIONEER, β_9, and NE × WGIC × PIONEER, β_{11}, in Equation 1. To test their joint impact in the two types of markets (H_2 and H_4), we must calculate and test ($\beta_8 + \beta_9$NE) and ($\beta_{10} + \beta_{11}$NE), respectively. Similarly, to test H_5 and H_6, the overall order-of-entry effect or pioneer advantage, we must calculate and test ($\beta_1 + \beta_7$NE + β_8CGIC + β_9NE × CGIC + β_{10}WGIC + β_{11}NE × WGIC). The vector CONTROL includes control variables such as radicalness (RDC_i), incumbency ($INCUMB_i$), technology intensity ($HTECH_i$), size ($Size_i$), product introduction year ($IntroYear_i$), pioneer lead time ($Lead_i$), and follower delay time ($Delay_i$), as well as their squared terms ($Lead_i^2$ and $Delay_i^2$). We discussed these variables previously and define them in Table 3. In addition, σ is the hazard function scale parameter. We estimate the AFT survival model (Equation 1) using the maximum likelihood estimation method (see model details in Web Appendix B at http://

[4]The radicalness measure has an average of 13.9 with a standard deviation of 1.72 for the pioneers and an average of 13.62 with a standard deviation of 1.87 for the early followers, which is close to the mean of 12.8 and standard deviation of 1.4 reported by Srinivasan, Lilien and Rangaswamy (2004).

[5]We also classified HTECH according to the percentage of industrial R&D funds relative to the total of industrial sales (Sarkar et al. 2006). We obtain the annual data on the percentage of industrial R&D funds to the total of industrial sales at the three-digit Standard Industrial Classification level from the Survey of Industrial Research and Development conducted by the National Science Foundation. Both approaches provide a consistent classification of technology-intensive products in the database.

TABLE 3
Variables Definitions

Variable	Definition
PIONEER	1 if the firm is market pioneer and 0 if otherwise.
NE	We adopt Srinivasan, Lilien, and Rangaswamy's (2004) measure: 2 = "extremely weak network effects," and 14 = "extremely strong network effects."
CGIC	1 if a product is incompatible with its previous generation and 0 if otherwise.
WGIC	1 if a product is incompatible with other products in its generation and 0 if otherwise.
INCUMB	1 if the firm also markets a product belonging to the previous generation of products that satisfied same customer needs and 0 if otherwise.
RDC	We adopt Srinivasan, Lilien, and Rangaswamy's (2004) and Chandy and Tellis's (2000) measure and add two dimensions: (1) whether a new technology incorporates a substantially different core technology on a scale from 1 to 9 and (2) whether a new product provides substantially greater customer benefits than the previous product generation in the category on a scale from 1 to 9.
HTECH	It is measured as a categorical variable that classifies product categories as high- or low-technology-intensive products. HTECH = 1 if the product is classified as a high-technology-intensive product, and HTECH = 0 if otherwise.
Size	1 if the number of employers of the firm is equal to or more than 100 and 0 if otherwise.
Lead	For the market pioneers, the natural logarithm of the lead time in years over the early followers and 0 otherwise.
Delay	For the early followers, the natural logarithm of the delay time in years after the pioneer's entry and 0 otherwise.
IntroYear	The natural logarithm of the introduction year.

www.marketingpower.com/jmjuly10). To increase the interpretability of the parameter estimates, we mean-centered continuous variables such as NE, radicalness, lead time, and delay time.

Results

We report the descriptive statistics of all variables in Table 4 and the results of the model estimation in Table 5. As Table 4 shows, for the 45 product categories in the study, the mean survival duration is 17.36 years for pioneers and 22.15 years for early followers ($p < .05$). This suggests that, on average, pioneers experience a survival disadvantage compared with early followers in these markets. As Table 5 shows, the estimation results show an overall goodness of fit ($\chi^2 = 66.30$, $p < .01$).[6] The coefficient of the variable PIONEER is significantly negative ($\beta_1 = -2.079$, $p < .10$), suggesting a negative main effect of entry order on firm survival. The coefficient of variable NE is also significantly negative ($\beta_4 = -1.278$, $p < .10$), suggesting a negative main effect of NE on firm survival. This finding is consistent with that discovered by Srinivasan, Lilien, and Rangaswamy (2004), who only examine pioneer firms.

[6]Using the same subsample of all pioneers, the model also shows a significantly better fit than that in Srinivasan, Lilien, and Rangaswamy's (2004) study ($\chi^2 = 8.36$, d.f. = 2, $p < .05$). In addition, the coefficients are significant for all product compatibility–related variables, which shows the importance of incorporating product compatibility in the study.

TABLE 4
Descriptive Statistics

	Pioneer (N = 45)		Early Follower (N = 55)	
Variable	**M**	**SD**	**M**	**SD**
Survival duration (years)	17.36	13.23	22.15	13.70
NE	7.67	2.23	7.97	2.15
CGIC	.73	.45	.76	.43
WGIC	.56	.50	.51	.51
RDC	13.90	1.72	13.62	1.87
HTECH	.73	.45	.69	.47
INCUMB	.42	.50	.49	.50
Size	.60	.50	.82	.39
IntroYear	7.59	.01	7.59	.01
Delay	4.82	9.04	3.13	3.32

TABLE 5
Empirical Results of Survival Duration in Markets with NE

Variable	Estimate	SE	Hypothesized Effects
Intercept (β_0)	3.263**	1.625	
PIONEER (β_1)	–2.079*	1.555	
CGIC (β_2)	–1.919	1.505	
WGIC (β_3)	1.617*	1.051	
NE (β_4)	–1.278*	.841	
NE × CGIC (β_5)	1.395**	.794	
NE × WGIC (β_6)	–.796*	.482	
NE × PIONEER (β_7)	1.292*	.854	
CGIC × PIONEER (β_8)	2.685**	1.551	
NE × CGIC × PIONEER (β_9)	–1.548**	.821	– (H_1)
WGIC × PIONEER (β_{10})	–2.253**	1.156	
NE × WGIC × PIONEER (β_{11})	.878**	.520	+ (H_3)
Control Variables			
RDC (β_{12})	.187	.123	
INCUMB (β_{13})	.488	.490	
HTECH (β_{14})	–.066	.636	
Size (β_{15})	1.293***	.464	
IntroYear (β_{16})	67.778*	43.963	
Lead (β_{17})	–.530	.616	
Lead × lead (β_{18})	.606*	.377	
Delay (β_{19})	–.993	.800	
Delay × delay (β_{20})	2.471**	1.056	
Scale parameter	.945		
Log-likelihood value	–86.093		
Goodness of fit (d.f. = 19)	χ^2 = 66.30***		
Sample size	N = 100		

*$p < .10$.
**$p < .05$.
***$p < .01$.

In the following discussion, we first present two new key results of the model: (1) the impacts of the two types of product incompatibility on pioneer survival advantage (H_1–H_4) and (2) the overall order-of-entry effects (H_5–H_6). We then discuss the robustness of the results.

Impacts of Product Incompatibility

H_1 and H_3 predict that NE influence the impact of the two types of product (in)compatibility on pioneer survival advantage in opposite directions: They decrease the impact of cross-generation incompatibility (H_1), but they increase the impact of within-generation incompatibility (H_3). As Table 5 shows, the coefficient of NE × CGIC × PIONEER is significantly negative ($\beta_9 = –1.548$, $p < .05$), but the coefficient of NE × WGIC × PIONEER is significantly positive ($\beta_{11} = .878$, $p < .05$). These results suggest that as NE increase, the impact of cross-generation incompatibility on pioneer survival advantage becomes weaker, whereas the impact of within-generation incompatibility becomes stronger. Thus, H_1 and H_3 are supported.

H_2 predicts that the impact of cross-generation incompatibility is positive on pioneer survival advantage in markets with extremely weak NE (H_{2a}) but negative in markets with strong NE (H_{2b}). To test these predictions, we rewrite the sum of factors with CGIC × PIONEER in Equation 1 as K_{cross} × CGIC × PIONEER, where $K_{cross} = \beta_8 + \beta_9 NE$. The coefficient K_{cross} represents the net impact of cross-generation incompatibility on pioneer survival advantage at each level of the NE. As Panel A of Table 6 shows, in markets with the lowest level of NE (NE = –6), the coefficient K_{cross} is significantly positive ($K_{cross} = 11.974 > 0$, $p < .05$), in support of H_{2a}.[7] Conversely, in markets with the highest level of NE (NE = 6), the coefficient K_{cross} is significantly negative ($K_{cross} = –6.605$, $p < .05$), in support of H_{2b}.

H_4 predicts that the impact of within-generation incompatibility is negative on pioneer survival advantage in markets with extremely weak NE (H_{4a}) but positive in markets with strong NE (H_{4b}). To test these predictions, we rewrite the sum of factors with WGIC × PIONEER in Equation 1 as K_{within} × WGIC × PIONEER, where $K_{within} = \beta_{10} + \beta_{11}NE$. The coefficient K_{within} represents the net impact of within-generation incompatibility on product pioneer advantage at each level of NE. As Panel A of Table 6 shows, in markets with the lowest level of NE (NE = –6), the coefficient K_{within} is significantly negative ($K_{within} = –7.518$, $p < .05$), in support of H_{4a}. Conversely, in markets with the highest level of NE (NE = 6), the coefficient K_{within} is positive ($K_{within} = 3.013$, $p < .10$), in support of H_{4b}.

Overall Order-of-Entry Effects

To test the overall order-of-entry effects, we rewrite the sum of factors with PIONEER in Equation 1 as $\Omega_{overall}$ × PIONEER, where $\Omega_{overall} = \beta_1 + \beta_7 NE + \beta_8 CGIC + \beta_9 NE \times CGIC + \beta_{10} WGIC + \beta_{11} NE \times WGIC$. The coefficient $\Omega_{overall}$ represents the overall order-of-entry effects on survival under different product compatibility conditions. Accordingly, a coefficient $\gamma_{overall}$ represents how the overall order-of-entry effect changes with the strength of NE, where $\gamma_{overall} = \partial\Omega_{overall}/\partial NE = \beta_7 + \beta_9 CGIC + \beta_{11} WGIC$. Panel B of Table 6 presents the results on the overall order-of-entry effects under different combinations of the two types of product compatibility. As Panel B of Table 6 shows, when products are cross-generation compatible but within-generation incompatible (CGC/WGIC), the pioneer survival advantage significantly increases with the strength of NE ($\gamma_{overall} = \beta_7 + \beta_{11} WGIC = 2.170$, $p < .01$), in support of H_{5a}. Furthermore, the overall order-of-entry effect is significantly negative ($\Omega_{overall} = –17.349$, $p < .01$) in markets with the lowest level of NE (NE = –6) but significantly positive ($\Omega_{overall} = 8.684$, $p < .05$) in markets with the highest level of NE (NE = 6). Thus, the results support H_{5b} and H_{5c}.

In contrast, when products are cross-generation compatible but within-generation incompatible (CGIC/WGC), as Panel B of Table 6 shows, the pioneer survival advantage significantly decreases with the strength of NE ($\gamma_{overall} = \beta_7 + \beta_9 CGIC = –.961$, $p < .01$), in support of H_{6a}. In markets with the lowest level of NE (NE = –6), the overall order-of-

[7]The original measure of NE is continuous between [2, 14] with an average of 8. Thus, the mean-centered measure is continuous between [–6, 6].

TABLE 6
Hypotheses Test Results

A: Impacts of Product Compatibility		
	Estimate	**Hypothesized Effects**
Cross-Generation Incompatibility		
β_9	–1.548** (.821)	– (H_1)
K_{cross}		
NE = –6	11.974** (6.191)	+ (H_{2a})
NE = 6	–6.605** (3.871)	– (H_{2b})
Within-Generation Incompatibility		
β_{11}	.878** (.520)	+ (H_3)
K_{within}		
NE = –6	–7.518** (3.893)	– (H_{4a})
NE = 6	3.013* (2.636)	+ (H_{4b})

B: Overall Order-of-Entry Effects		
	Estimate	**Hypothesized Effects**
Cross-Generation Compatible/ Within-Generation Incompatible		
$\gamma_{overall}$	2.170*** (.896)	+ (H_{5a})
$\Omega_{overall}$		
NE = –6	–17.349*** (6.757)	– (H_{5b})
NE = 6	8.684** (4.240)	+ (H_{5c})
Cross-Generation Incompatible/ Within-Generation Compatible		
$\gamma_{overall}$	–.961*** (.288)	– (H_{6a})
$\Omega_{overall}$		
NE = –6	2.144* (1.721)	+ (H_{6b})
NE = 6	–.934 (2.036)	– (H_{6c})

*$p < .10$.
**$p < .05$.
***$p < .01$.
Notes: Sample size: N = 100. NE is a mean-centered continuous variable. The mean value is 8. Numbers in parentheses are estimated standard errors. Parameters β_9, β_{11}, K_{cross}, $K_{withing}$, $\gamma_{overall}$, and $\Omega_{overall}$ are based on Model 1 and estimates in Table 5; the dependent variable is the survival duration.

entry effect is significantly positive ($\Omega_{overall} = 2.144$, $p < .10$), in support of H_{6b}. Finally, the overall order-of-entry effect has the predicted negative sign but is not significant ($\Omega_{overall} = -.934$, $p > .10$) in markets with the highest level of NE (NE = 6).

Robustness and Validity of Results

We examine the sensitivity and validity of the estimations with several additional analyses. First, instead of assuming the Weibull baseline distribution, as in Equation 1, we estimate the AFT model by assuming two other commonly used baseline distributions: lognormal and log-logistic distributions. Based on these two alternative assumptions (see the estimation results in the second and third columns of Web Appendix C at http://www.marketingpower.com/jmjuly10), the results are consistent with those in Table 5. Second, in addition to using the AFT model, we estimate a proportional hazard model (e.g., Cox and Oakes 1984; Kalbfleisch and Prentice 1980). The signs of the estimates in the proportional hazard model are opposite to those in the AFT model because the former assumes the impacts of variables on the hazard rate while the latter assumes the impacts of variables on the time to survive. The two models lead to the same patterns as in Table 5 (see the results in the fourth column of Web Appendix C). Third, we estimated a frailty model (e.g., Xue and Brookmeyer 1996) to determine whether the hazard rates of pioneers and followers are correlated. The results show that the correlated hazard parameter is not significant (see the results in the fifth column of Web Appendix C). This suggests that estimating the impacts of product compatibility on the survival duration of pioneers and followers in a single hazard model is valid in the data.

Finally, we apply jackknife cross-validation methods to show the predictive validity of the model (Hinkley 1983). Specifically, we hold out one observation each time and reestimate the remaining sample. We then use the estimated parameters to predict the median survival time for the holdout product and calculate the 95% prediction interval. The prediction accuracy rate is assessed by whether the observed survival time for the holdout product falls in the prediction interval (e.g., Claret et al. 2009). Compared with the baseline model (i.e., the AFT model without all covariates in Equation 1), our model improves the prediction accuracy rate from 46% to 87%.[8]

[8]We also compared the prediction accuracy rate with Srinivasan, Lilien, and Rangaswamy's (2004) model, using the same subsample of all pioneers. Our model improves the prediction accuracy rate from 80% to 84%.

General Discussion

Research Contributions

This research contributes to the NE literature by taking the first step toward directly testing how the order of market entry (i.e., pioneers versus early followers) and product compatibility may affect firm survival duration in NE markets. We show that in NE markets, the two types of product compatibility, cross- and within-generation compatibility, affect pioneer survival advantage in different ways. We also find that both the magnitude and the direction of these impacts are contingent on the strength of NE. This research makes a conceptual contribution by proposing some systematic patterns within these complicated contingency relationships. To our knowledge, this is the first study to provide empirical evidence as to how pioneers can have a survival advantage over their early followers in markets with NE and under different compatibility conditions.

This research also contributes to the order-of-entry literature by explicitly comparing the survival duration of pioneers with that of early followers. We show that pioneers have a lower average survival duration than early followers (17 versus 22 years; see Table 4). The survival analysis further shows that the ultimate effects of order of entry and pioneer advantage are jointly determined by two important market characteristics: the relative strength of NE and product compatibility. The growing importance of NE throughout the economy makes this a significant finding.

Managerial Implications

The installed-user-base effect, a unique characteristic of markets with NE, is a double-edged sword for a market pioneer's survival: While it imposes a high first-mover risk because of the unique start-up difficulty (zero or small installed base at product launch), it also provides a high first-mover benefit because the established installed base creates entry barriers and competitive advantages. To be successful in markets with NE, managers need a deeper understanding of the overall impact of NE on survival as well as the impact of more specific product–market factors. The findings provide useful managerial implications for firms in these markets. To illustrate some specific managerial insights, using the estimated parameters based on the data of 45 product categories in this study, we simulate the survival probabilities for both pioneers and followers under different product compatibility conditions and with varying degrees of NE strength. Specifically, we simulate survival rates for both pioneers and followers, given the model (Equation 1) and the estimated parameters in Table 5, under four market conditions in terms of the two types of product compatibility:

1. Both incompatible (CGIC/WGIC).
2. Both compatible (CGC/WGC).
3. Cross-generation incompatible but within-generation compatible (CGIC/WGC).
4. Cross-generation compatible but within-generation incompatible (CGC/WGIC).

For each case, we vary the strength of NE while keeping the control variables at average values across all product categories in the data set. We present the simulated survival probabilities at the fifth year from the time of market entry in Figure 2, Panel A (pioneers) and Panel B (followers), respectively.[9] We also present some comparisons of pioneers and followers in Figure 2, Panels C and D. These figures illustrate how crucial it is for firms in markets with NE to understand the three factors that jointly affect their survival: (1) product compatibility, (2) strength of NE, and (3) order of entry.

We offer the following specific managerial insights: First, it is important for firms to understand that NE is *not* necessarily a threat to the survival of pioneers. As Figure 2, Panel A, shows, with a cross-generation compatible but within-generation incompatible product, pioneers achieve higher survival probability with a higher level of NE. This suggests that innovating firms facing strong NE should not hesitate to be the first to enter the market simply because of the high risk in such markets. The consideration of the impact of NE on pioneers' survival must be compatibility specific.

Second, it is important to understand that in the presence of NE, the conditions facilitating pioneers' survival do not necessarily favor later entrants' survival. For example, in the presence of strong NE, it is the best survival condition for pioneers (see Figure 2, Panel A) but the worst survival condition for followers (see Figure 2, Panel B) when a product is cross-generation compatible but within-generation incompatible. This finding suggests that it is not always in later entrants' best interest to follow the same product compatibility choices of the market pioneers, even if those choices have been successfully accepted by the market.

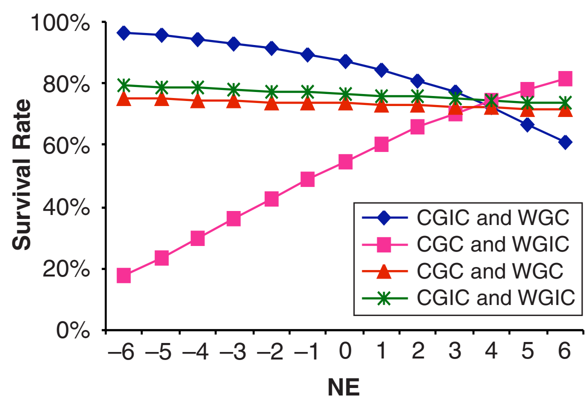
Third, although on average pioneers have a higher failure rate than early followers in NE markets, opportunities exist for pioneers to enjoy a survival advantage. Indeed, market pioneers can have a survival advantage in markets with both strong and weak NE, but under different compatibility conditions. As Figure 2, Panel C, shows, in markets with weak NE, firms can have a pioneer advantage if their products are compatible with those of their competitors but not with those of the previous generation. However, as Figure 2, Panel D, shows, in markets with strong NE, firms can gain a pioneer advantage when their products are compatible with the previous-generation products, even if they are not compatible with those of their followers.

The loss of CBS color television to RCA color television highlights the importance of being compatible with previous-generation products (B&W televisions) in strong NE markets. In contrast, cross-generation incompatibility has helped Logitech gain a pioneer advantage in the digital camera market, in which the strength of NE is relatively low because consumers can share their photos easily through common file formats (e.g., JPEG). The digital camera, first commercialized by Logitech in 1991, does not allow consumers to use film and thus is cross-generation incompatible with traditional cameras. However, it allows consumers to

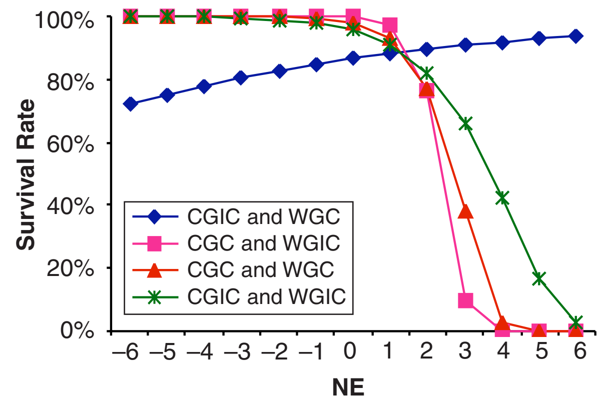
[9]We find a similar pattern for the ten-year survival rates.

FIGURE 2
Simulated Survival Rates for Pioneers and Followers Under Four Different Compatibility Conditions

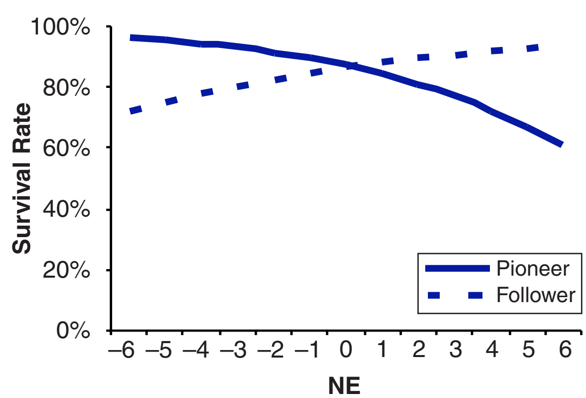
A: Five-Year Survival Rate of Pioneers Under Four Compatibility Conditions



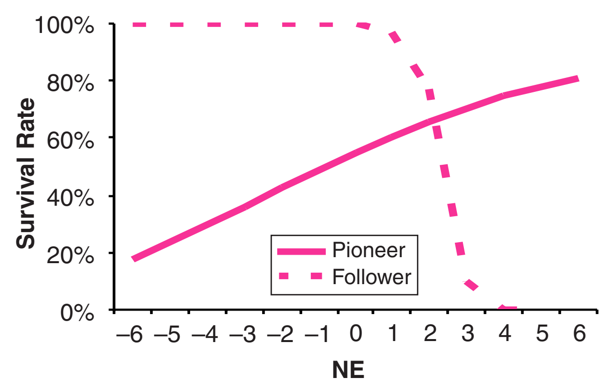
B: Five-Year Survival Rate of Followers Under Four Compatibility Conditions



C: Five-Year Survival Rate When the Product Is CGC and WGC



D: Five-Year Survival Rate When the Product Is CGIC and WGIC



Notes: NE is mean centered. The mean value is 8. Sample size: N = 100. The survival rates for pioneers and followers under different conditions are simulated on the basis of Model 1 and the estimated parameters.

take, store, edit, and transfer photos in a new and convenient way. The significant product differentiation resulting from cross-generation incompatibility has helped Logitech redefine consumers' preferences in the digital and online image market. Meanwhile, because of the relative weak NE, such incompatibility does not have a major negative impact on consumers' adoption risk. As a result, the positive consumer preference effect dominates the negative market uncertainty effect, and thus Logitech has gained a pioneer survival advantage in this market.

Fourth, firms in NE markets can also gain some new insights into their entry decisions. As Figure 2, Panel B, shows, in markets with strong NE, the market follower has a significantly higher survival rate when its products are cross-generation incompatible and within-generation compatible than under the other three product compatibility conditions. This finding suggests that it is important for a potential later entrant to consider product compatibility conditions when deciding whether to enter a new market with strong NE. Specifically, if survival is the most important consideration, later entrants should consider entering the market only if there are few barriers for them to achieve within-generation compatibility with pioneers.

Finally, the findings provide useful insights into a firm's product decision making. Often, product compatibility is achieved as a result of a technology revolution or by industry negotiation and government intervention. However, for some products, firms have leverage on their compatibility. The results suggest that the two types of product compatibility should be treated differently. Specifically, cross-generation incompatibility can cause pioneers to lose market leadership in markets with strong NE: CBS lost its market leadership because of its cross-generation incompatibility with B&W televisions; however, RCA, the later entrant, overcame CBS's pioneer advantage by making its color television compatible with the older-generation B&W televisions. In contrast, within-generation incompatibility can help market pioneers deter potential entry (e.g., IBM's decision not to introduce its 4-inch FDD in light of the success of Sony's 3.5 FDD) and sustain their first-mover advantage in those markets. Caution should be exercised, however, when drawing managerial implications on firms' product decisions based on within-generation compatibility: Sometimes, the status of such compatibility may not be known to the pioneers at the time of entry, or firms may lack the ability to determine it.

Limitations and Directions for Further Research

This research has several limitations. First, as in other studies using historical methods, the data set only includes products that we could find in historical records, and products that have existed in markets for a short time may not be identifiable because of missing archival records. Second, in line with Srinivasan, Lilien, and Rangaswamy's (2004) study, we use subjective measures for NE. If future studies were to use objective measures, they could provide additional insights into this issue. Third, this research focuses only on the survival duration of a product. In practice, firms may have other objectives in different markets or at different times. Further research could explicitly examine how NE and product compatibility jointly affect firms' performance in other areas.

Furthermore, the results illustrate the differential impacts of the two types of incompatibility on pioneers' survival advantages. A potentially important area of further research would be exploring how the effectiveness of firms' marketing strategies might be affected differently by the two types of compatibility. For example, preannouncement of new products is a widely adopted practice. The incentives for preannouncement are stronger in NE markets because they may motivate consumers to delay their purchases and slow the buildup of the installed base of incompatible technologies. However, they may also motivate the existing adopters of competing technology to join the standards war, especially given advances in information technology and the fast growth of social networking (e.g., various anti-DivX Web sites launched by consumers soon after the product announcement by Circuit City). It would be worthwhile to examine whether preannouncement affects the innovating firm differently under the two types of incompatibility.

Finally, this work focuses on how order-of-entry effects are contingent on product compatibility in NE markets. Further research might explore how other potentially significant contingent factors influence pioneers and followers in these markets.

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