M A R K E T I N G S C I E N C E I N S T I T U T E

The Incumbent's Curse?
Incumbency, Size, and Radical Product Innovation

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A common perception in the field of innovation is that large, incumbent firms rarely introduce radical product innovations. Such firms tend to solidify their market positions with relatively incremental innovations. They may even turn away entrepreneurs who come up with radical innovations, although they themselves had such entrepreneurial roots. As a result, radical innovations tend to come from small firms, the outsiders.

This thesis, which authors Chandy and Tellis term the "incumbent's curse," is commonly accepted in academic and popular accounts of radical innovation. Yet a review of the literature suggests that the evidence for the incumbent's curse is based on anecdotes and scattered case studies of highly specialized innovations. It is not clear if it applies widely across several product categories.

Chandy and Tellis re-examine the incumbent's curse using an historical analysis of a relatively large number of radical innovations in the consumer durables and office products categories. In particular, they seek to answer the following questions:

- How prevalent is this phenomenon? What percentage of radical innovations do incumbents, versus nonincumbents, introduce? What percentage of radical innovations do small firms, versus large firms, introduce?
- Does the phenomenon invariably afflict large incumbents in current industries? Is it driven by incumbency or size?
- How consistent is the phenomenon? Has the increasing size and complexity of firms over time accentuated it? Does it vary across national boundaries?

Results from the study suggest that the conventional wisdom on the incumbent's curse may not necessarily be valid, and that incumbents or large firms are not necessarily doomed to obsolescence by nimble outsiders. Among the results:

- In the consumer durables and office products categories, over a 150-year period, small firms and nonincumbents introduced slightly more radical product innovations than large firms and incumbents.

- However, the sources of radical product innovations in the sample changed substantially after World War II. Large firms and incumbents introduced a majority of radical product innovations after this time period.
- The U.S. accounts for close to two-thirds of radical product innovations in the sample, while Western Europe accounts for most of the remaining. Japan accounts for only a few innovations, but those have been entirely in recent years. The distribution of radical innovations between the U.S. and other nations has remained steady over time.
- Small firms and outsiders account for many more innovations in the U.S. than they do in other countries. Thus, the incumbent's curse is less prevalent in Western Europe and Japan than in the U.S.
- Dynamic organizational structures and strong technological capability are factors that may help large, incumbent organizations to remain nimble and innovative.

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Introduction

> One lesson from stories of corporate innovation is that it's rare for incumbent firms in an industry to reinvent that industry. Leadership in the typewriter industry, for example, changed hands from Remington to Underwood to IBM (with the "golf-ball" typewriter) to Wang (with the advent of word-processing) and now to Microsoft. Never once did the leader at a particular stage pioneer the next stage. (*Business Times,* 1996, p. 9)

> [T]he most important breakthroughs in military technologies have come not from the one or two companies that were the incumbent contractors in a category, but from wannabe's and upstart firms hoping to challenge them. (*The Washington Post,* 1997, p. F05)

Reports about radical product innovation often follow this script. An entrepreneur, working either independently or within a corporate setting, invents a design for a radically new product. This person then makes the rounds of incumbents in the industry, seeking support to further develop and commercialize the revolutionary product. But the entrepreneur encounters indifference or even hostility from the incumbents. After much search and hard work, the entrepreneur manages to piece together the funds to introduce the radically new product. In some cases, the product takes off. The entrepreneurial firm succeeds well beyond the expectations of its founder, generally at the expense of the incumbents that resisted the innovation. Declining sales of the older product cause the incumbents to lose their secure positions, and the entrepreneurial firm comes to dominate the transformed market. Ironically, once the new firm becomes entrenched in the market, it suffers from the same curse that afflicted incumbents in the previous product generation. When the next wave of radical product innovation hits the market, this firm resists it, just as its predecessors had resisted the current product. This resistance to innovation leads to its own decline or demise, and the cycle continues.

The literature frequently describes the above sequence of events when recounting the development of radically new products. Chester Carlson (dry copiers) is a classic example (Dessauer 1971; Hiltzik 1999; Smith and Alexander 1988). Recent research in technology management, economics, and marketing supports all or parts of this script (e.g., Christensen 1997; Ghemawat 1991; Henderson 1993; Utterback 1994). We term this thesis the "incumbent's curse," since it argues that incumbents in a particular product generation are so enamoured with their success or so hampered by their bureaucracy that they fail to introduce the next generation of radically new products.

For example, Henderson (1993, p. 248) argues that incumbents' efforts with respect to radically new technologies are characterized by "incompetence" and "underinvestment." Ghemawat (1991, p. 161) suggests that incumbents are prone to "technological inertia," due to their many investments in the existing market.

Scherer (1980, p. 438) cites cases to argue that "new entrants contribute a disproportionately high share of all really revolutionary new industrial products and processes." Some authors claim that established firms are slow to introduce not only radical product innovations, but also "seemingly minor" changes (Henderson and Clark 1990, p. 9). Every change in configuration in the computer disk drive industry (e.g., from 8-1/2-inch disks to 5-1/4-inch disks to 3-1/2-inch disks) was initiated by a nonincumbent, and led to the downfall of the previously dominant firm (Christensen 1993). Indeed, Rosenbloom and Christensen (1994, p. 655) note that the inability or unwillingness of incumbents to introduce radically new products is one of the prominent "stylized facts" in the literature on innovation management.

However, the above conclusions are based on case studies of individual products, not on cross-sectional studies that use large samples of products (e.g., Ghemawat 1991; Henderson and Clark 1990; Mitchell 1991). The cases studied have been quite specialized, including photolithographic aligners (Henderson and Clark 1990; Henderson 1993), medical diagnostic imagers (Mitchell 1991), and private branch exchanges (Ghemawat 1991). The few multi-product studies that exist use convenience rather than formal sampling (Cooper and Smith 1992; Rosenbloom and Christensen 1994; Tushman and Anderson 1986; Utterback 1994). Moreover, most of these studies are in the U.S. This state of knowledge raises the following questions:

- How pervasive is the phenomenon of the incumbent's curse? In particular, what percentage of radical innovations follow the script outlined above?
- How consistent is the phenomenon? Has the increasing size and complexity of firms over time accentuated it? Does it vary across national boundaries?
- Is the phenomenon a curse that invariably afflicts large incumbents in current industries? Is it driven by incumbency or size?

The current study seeks to address these questions. Research on this topic is important for several reasons. First, radical innovation is an engine of economic growth and a source of better products. An understanding of these issues is important for consumers and public policy makers. Second, radical innovation changes the entire shape of industries and may mean either life or death for many firms (e.g., see Cooper and Schendel 1976; Schumpeter 1942). Indeed, the history of business is marked by the deaths of entire industries that were destroyed by radical product innovations. The telegraph, gas lighting, and typewriter industries are cases in point. Thus, managers need to know how to initiate and manage radical product innovation. Third, many large incumbents, especially in technologically intense industries, spend huge resources on research and development. A confirmation of the incumbent's curse would suggest the need for a reconfiguration either of their resources or of their departments responsible for innovation. For example, after listening to speaker after speaker emphasize the incumbent's curse at the Marketing Science Institute's 1997 conference on "Really New Products," one senior manager from a large multinational firm commented that his overarching feeling was "one

of hopelessness." More research on the extent and causes of these problems may engender insight instead of hopelessness. This is the goal of the current study. It aims to build on a burgeoning stream of research in the marketing literature on the sources of radically new products and the characteristics of radically innovative firms (e.g., Gatignon and Xuereb 1997; Ghemawat 1991; Moorman and Miner 1997; Olson, Walker, and Ruekert 1995). The next three sections describe the theory, method, and results of this study. The last two sections discuss the implications and limitations of the research.

Theory

This section defines the main variables, presents the theory underlying the study, and presents alternate theories to explain various aspects of the phenomena.

Definitions

A *radical product innovation* is a new product that incorporates a substantially different core technology and provides substantially higher customer benefits relative to previous products in the industry (Chandy and Tellis 1998). A *radical product innovator* is the firm that first commercializes a radical product innovation (Ettlie and Rubenstein 1987). In an innovation context, incumbency reflects whether a firm participated in the previous generation of products. Thus an *incumbent* is a firm that manufactured and sold products belonging to the product generation that preceded the radical product innovation (Henderson 1993; Mitchell 1991; Mitchell and Singh 1993). *Firm size* refers to the scale of operations of an organization (Price and Mueller 1986).

To provide a theoretical background to understand the behavior and performance of firms in the realm of radical innovations, we next discuss the theory of S-curves.

Theory of S-Curves

The theory of S-curves comes from the technology management literature and explains the origin and evolution of radical innovations (Foster 1986; Sahal 1985; Utterback and Abernathy 1975; Utterback 1994). This theory suggests that technologies evolve along a series of successive S-curves that drive various new product introductions (Chandy and Tellis 1998, see Figure 1). The S-curve emerges because a new technology offers few consumers benefits when first introduced, increases rapidly in consumer benefits as the technology develops, but improves quite slowly as the technology matures.

Figure 1. S-Curves

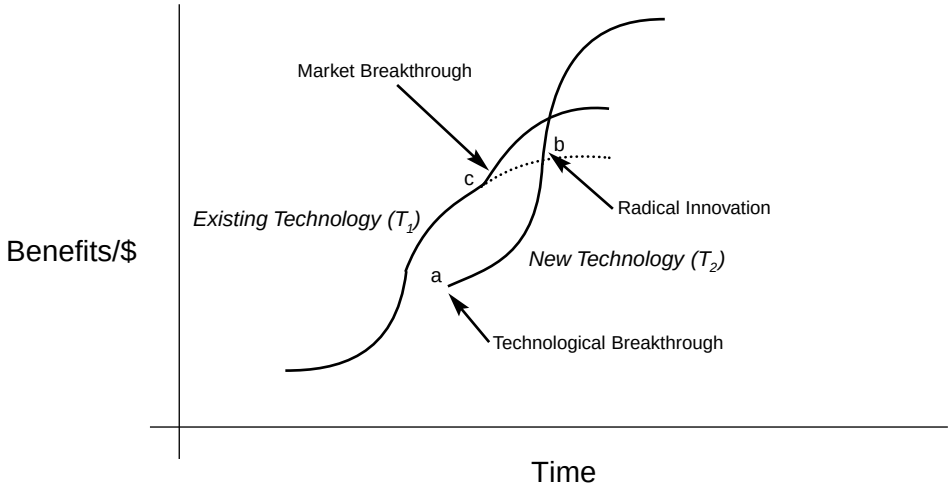


Figure adapted from Chandy and Tellis (1998)

To better understand this phenomenon, consider an existing technology (T_1), which is in its maturity. Assume that at some point during the maturity of this technology, a new technology, T_2, emerges, leading to a new product, called a *technological breakthrough* (a). Initially, because of problems implementing the technology, T_2's benefits are inferior to those of T_1. So the new product's sales are below those of existing products, and occur mostly to highly innovative, price-insensitive consumers. However, with research, T_2 begins to improve rapidly in consumer benefits and ascends its own S-curve. A point comes (b) when T_2 may pass the existing technology, T_1, in benefits. At this point, the market considers the new product based on T_2 a *radical product innovation*. Sales of the new product then begin a *takeoff* as consumers increasingly shift to the new product to satisfy their needs. Sales of the old product may begin a corresponding decline.

Faced with this competition, supporters of the old technology, T_1, may make a renewed effort to be competitive by redoubling their efforts in the old technology. This effort may result in some short-term improvement in T_1, called a market breakthrough (c). However, investments in the new technology, T_2, generally yield much greater benefits to consumers than do those in T_1. So products based on T_2 continue to outsell those based on T_1. The old product dies out when the new product completely replaces it.

As time passes, T_2 ceases to improve substantially, and sales based on the new product slow down. If another radical product innovation emerges, the cycle may repeat itself. If this new innovation never surpasses the old one in consumer benefits, it dies out without ever triggering a takeoff.

Incumbents and Radical Innovation

The theory of S-curves suggests three reasons why incumbents may be reluctant to introduce radical innovations: perceived incentives, organizational filters, and organizational routines.

Perceived Incentives. Incumbents may perceive smaller *incentives* to introduce radical product innovations than do nonincumbents (Conner 1988; Scherer 1980; see Tirole [1988] for a more nuanced analytical view). The reason is that they derive a significant stream of rents from existing products based on the current technology, while nonincumbents derive no such rents. Note from Figure 1 that radically new products hold the potential to make existing products obsolete. Introducing a radically new product could therefore jeopardize the rents from existing products. Incumbents therefore have a lower marginal incentive than do nonincumbents to develop or commercialize radical innovations in the short term (Reinganum 1983; Ali 1994). Indeed, mathematical models of innovation indicate that incumbents would maximize overall profits by *not* introducing a radical product innovation *even when* (1) the radical innovation itself is more profitable than the existing product (Reinganum 1983), and (2) the fixed cost of offering the radical innovation is zero (Ghemawat 1991). What these models do not fully take into account is the dynamic nature of the radical innovations that can completely render obsolete the old products and completely replace the existing market in the long run.

Organizational Filters. Organizational theorists argue that the *organizational filters* of incumbents make them less effective at radical innovation (e.g., Henderson and Clark 1990; Hannan and Freeman 1977; Nelson and Winter 1982). Organizational filters are cognitive structures that screen out information unrelated to tasks that organizations deem important, to better focus their attention on these tasks. Incumbents' success in the *current* product category is partly due to organizational filters that allow them to efficiently focus on their *current* challenges. In particular, these filters help them to process consumer requests or complaints, channel them to the manufacturing department or distributors, and ensure that the current products meet consumer expectations as effectively as possible. Thus the filters serve to direct managers' attention to maximize the utility of the current technology for current customers. However, radical product innovations involve a substantially new technology. As a result, these very organizational filters may cause incumbents to be less effective than nonincumbents at spotting, developing, and marketing radical product innovations (Henderson 1993).

Organizational Routines. Organizational theorists also state that incumbents develop *organizational routines* or procedures to efficiently carry out the repetitive tasks of manufacturing and distributing large volumes of the current product (Henderson and Clark 1990; Hannan and Freeman 1977; Nelson and Winter 1982). Within the R&D department, the routines are geared toward efficiently developing *incremental* innovations based on the current technology. However, the routines are ineffective at developing *radical* product innovations, because the latter are based on a substantially different technology (Henderson 1993). Moreover, adoption of radical innovations would render obsolete many of these routines and require the development of new routines, which is difficult, costly, and risky

(Hannan and Freeman 1977; Nelson and Winter 1982). Managers may reason that these very routines have helped the firm ride through the success of the current technology. Thus they have a vested interest in the current organizational routines (Staw 1981), and are reluctant to embrace radical innovations.

Opportunities of Incumbents. While the above theory suggests that incumbents are less likely to innovate radically than nonincumbents, incumbents have increased opportunity to innovate in terms of market capabilities (e.g., Srivastava, Shervani, and Fahey 1998). Indeed, if incumbents can muster the willingness to cannibalize their own investments (Chandy and Tellis 1998) they can exploit their many resources to lead with radical innovations. We highlight three market capabilities—customer knowledge, customer franchise, and market power—and note the opportunities they create for radical innovation.

First, incumbents have greater knowledge about customers in the market. They communicate with them, understand their needs, and may have detailed records of their purchases and behavior. Thus, they may be better able to gauge the value of radical innovations than nonincumbents, and market them when they are introduced. Second, incumbents enjoy a customer franchise that can be beneficial in the context of radical innovation. Consumers perceive radical product innovations as risky purchases (e.g., Bauer 1960; Folkes 1988). To the extent that consumers in a particular market are familiar with an incumbent, they would be less apprehensive about purchasing a radical product innovation from this firm. Third, incumbents also possess greater market power, which gives them preferential access to distribution channels relative to nonincumbents (Mitchell 1989). It may also allow them to sustain their market presence during the long and unprofitable period until the product takes off. Recent research indicates that this period till takeoff has averaged 17.7 years for products introduced before World War II, and 5.8 years for products introduced after World War II (Golder and Tellis 1997; also see Urban and Hauser 1993).

Summary. The literature and extant theory strongly suggest that incumbents are less likely than nonincumbents to introduce radical innovations. At the same time, incumbents have many market capabilities to do so. Though the focus of empirical studies so far has been mostly on noninnovative incumbents, at least some incumbents may actually be successful at developing and introducing radical innovations. This conflict underscores the need for empirical research, based on a large cross-section of innovations, which can identify the actual pattern of radical innovation by incumbents.

Firm Size and Radical Product Innovation

Incumbents that have successfully survived in a market tend also to be large. Thus, size and incumbency are likely to be positively correlated. Our concern is about the role of size in radical innovation after controlling for the influence of incumbency. Here again, the literature strongly suggests that large firms may not be radical innovators primarily due to inertia (Acs and Audretsch 1991; Cohen 1995; Cohen and Levin 1989; Scherer 1991). We review the theory of inertia below, and then briefly discuss the opportunities of large firms.

Theory of Inertia. As firms grow large, they are prone to the forces of bureaucratic inertia (Tornatzky and Fleischer 1990). With a large number of employees, large firms typically develop layers of administrative staff and formal rules of communication to manage them (Blau and Schoenherr 1971; Kasarda 1974; Terrien and Mills 1955). While such bureaucracy may help large firms to function more effectively in serving current customers with current technology, they can also render them slow to react to radically new products (e.g., Kimberly 1976).

Note from Figure 1 that radical innovations are not merely an outgrowth of the current technology, but result from the application of a substantially different technology to the same problem. In a large firm, new ideas that give birth to radical innovations have to move through more layers of administration, and innovative employees often have to labor through bureaucratic resistance to get approval for their ideas. The process increases the likelihood of screening or tempering of radical ideas. Alternatively, the time and trouble it takes to gain approval distracts scientists from concentrating on creative work (Acs and Audretsch 1991; Scherer 1980). In the extreme case, it can frustrate innovators and lead them to look elsewhere for support, or to start their own company.

A related problem is that of rewards for innovators in large organizations. As organizations grow in size, they involve more levels of screening and group decision making. Thus, the contributions of individuals get increasingly dilute. So individual innovators are less able to capture the benefits of their innovative efforts (Cohen 1995; Schumpeter 1942), and have fewer incentives to develop radically new products (Cohen and Levin 1989). In sum, large firms are less likely than small firms to provide the responsive, risk-taking atmosphere needed for the development of radical product innovations.

Opportunities of Large Firms. Large firms do have great opportunities to develop and introduce radically new products. In particular, large firms have enormous financial and technical capabilities, which they can harness for radical innovation.

Large firms may have the economies of scope to spread the risks of new ventures widely (Arrow 1962; Galbraith 1968). Similarly, large firms have a large volume of sales over which to spread the fixed costs of R&D (Comanor 1967). As a result, large firms are less vulnerable to the failure of a particular development project, since it would entail a smaller proportion of their resources than it would for a small firm.

The deeper pockets of large firms also allow them to maintain state-of-the-art scientific facilities, and hire quality scientific personnel. Moreover, some researchers argue that capital market imperfections provide an advantage to large firms because they have greater access to internal and external funds to finance risky research and development projects (Cohen and Levin 1989). Thus, large firms may be more capable of pursuing radical innovations than small firms.

Summary. The theory of inertia strongly suggests that large firms would be unlikely to introduce radical innovations. At the same time, large firms have many financial and technical capabilities to do so. Thus, there is a conflict about the role of size on radical innovation. This conflict began with the work of Schumpeter (1942)

and continues today (Chandy and Tellis 1998). Empirical research that helps to enlighten the debate would be useful.

Country, Incumbency, and Radical Innovation

The proportion of innovations from incumbents relative to nonincumbents is likely to be lower in the U.S. than in other industrialized nations, such as Japan and Western Europe (Acs and Audretsch 1991; Imai 1990; Scherer 1991). The reason for this difference may be differences in institutions and popular culture between the U.S. and the other nations (Patel and Pavitt 1995).

Institutions. The U.S. has historically enjoyed an active market for venture capital, which makes financing for less established firms easier in the U.S. than in many other countries (Saxenian 1994). Thus financial institutions may play a role in encouraging radical innovation among less established firms in the U.S. relative to Japan and Europe. At the same time, government policies in the latter countries have traditionally favored technology ventures by large, established firms over those by small firms (Fitzroy and Kraft 1991; Scherer 1991; Urabe, Child, and Kagono 1988). Large incumbents in these countries enjoy financial and technological support that is unavailable to similar firms in the U.S. (Magaziner and Patinkin 1989). Thus incumbents and large firms in Japan and Europe are more likely to indulge in radical innovations that those in the U.S.

The Entrepreneur in Popular Culture. Popular culture in the U.S. celebrates risk takers. Indeed, the American entrepreneur is a celebrated figure—the pride of Americans, the ideal of would-be entrepreneurs, and the envy of foreigners seeking to emulate his or her success. In the U.S., failure is stigmatized less than in some other countries (see Patel and Pavitt 1995). On the contrary, succeeding after a string of failures enhances the glory of the entrepreneur. Hence individuals are motivated to engage in entrepreneurial ventures to commercialize new technology, more so in the U.S. than in other countries. This factor could increase the pool of small, nonincumbent firms that are likely to become radical innovators in the U.S.

Summary. Based on the above arguments, we expect the profile of U.S. radical innovators to be different from that of non-US radical innovators. Specifically, we expect more U.S. innovators to be small firms or nonincumbents than we expect innovators from other countries (especially Japan and Western Europe). Stated differently, the incumbent's curse is more likely to apply in the U.S. than in non-U.S. contexts.

Table 1 summarizes the theoretical discussion and the hypotheses it suggests. The next section describes our research approach, sampling frame, and measures to test these hypotheses.

Table 1. Summary of Theoretical Discussion

Type of Firm	Theory *Against* Radical Innovation	Theory *for* Radical Innovation
Incumbent	Incentives, filters, and routines enhance commitment to current technology	Market capabilities facilitate radical innovation
Large Firm	Bureaucratic inertia dampens radical innovation	Financial & technical capabilities facilitate radical innovation
U.S. Nonincumbents		Institutions and culture foster radical innovation by entrepreneurs

Method

Research Approach

We had to collect our own data to address the questions posed above, because we could not find any satisfactory database of radical innovations. We used the historical approach to data collection (Savitt 1980; Smith and Lux 1993) for three reasons. First, the events we study occurred in the past. Many occurred in the very distant past. Second, the easier alternate approach of surveying current managers could suffer from severe memory or self-report biases. Third, the historical approach allows us to study the effects of time on the incumbent's curse. Specifically, this approach can provide an answer to the question: Are today's incumbents more or less innovative than the incumbents of the distant past? An understanding of temporal changes requires attention to the time order of events that is best obtained by the historical approach. Historical research is tedious and time consuming, but well worth the effort in terms of insight and novelty of findings. Thus in scope and design, our study is similar to Golder and Tellis (1993), though in content it is similar to Foster (1986) and Utterback (1994).

We use the following five criteria to include data in our study:

1. *Confirmation:* at least two published sources cite the same fact
2. *Neutrality:* the sources had no overt interest to bias their report
3. *Independence:* the sources were based on independent observation (i.e., they did not both come from a single source such as UPI)
4. *Reliability:* the sources were well respected or had a history of good reporting
5. *Contemporaneity:* the sources reported as close to the time of the event as possible

Overall, we used information from over 250 books and 500 articles in periodicals. The information search and data collection tasks were time and effort-intensive. They required the effort of one researcher and nine trained assistants, working over a period of four years.

Sampling Frame

To avoid sampling biases, we used a relatively formal sampling frame to choose the product categories and innovations for our study. This approach contrasts with past research, which relied on convenience samples. We chose the sample to satisfy three objectives.

- First, in the interests of time and effort, we restricted our study to two broad product classes: consumer durables and office products. These two product classes have been studied in previous research, especially in the literature on innovation diffusion and market pioneering (Golder and Tellis

1993, 1997; Gort and Klepper 1982; Sultan, Farley, and Lehmann 1990). The current research on these categories can add to the cumulative knowledge in the area. These two product classes are also attractive because innovations in these classes have widely varying dates of introduction. Thus they allow us to identify generalizations over time or historical trends in the pattern of radical product innovation.

- Second, we wanted the product categories in the two classes to have high unit sales. In practice, we restricted the sample to categories with more than a million units in sales in 1994, the last year for which sales data were available when this study began. This cutoff value for sales is a conservative figure; it ensured that the categories in our sample would include innovations that truly had a large enough impact on consumers so as to form huge markets. We obtained the list of categories and their annual sales from the 1994 volume of *Predicasts*. This goal led to a list of 49 product categories.

- Third, we wanted the core technology used in at least one innovation in the category to shift substantially from the technology used in the previous product generation. Prior theory suggests that it is such shifts in technology that trip incumbents (Cooper and Smith 1992; Utterback 1994). To determine a radically new technology in each category, we used a two-step procedure. First, we identified the most significant product innovations in each product category. We obtained information on the innovations from books on the history of the respective categories, as well as from past issues of business and technology periodicals. To ensure the eligibility of information and to increase relevance to current products, we restricted the sample to innovations introduced after 1850. The procedure led to 93 significant innovations. Finally, a team of three experts rated each significant innovation for its radicalness relative to the previous product generation. We describe the rating procedure in greater detail later in the measures subsection below.

Our sample size compares favorably to those in other empirical studies on consumer durables. Sultan, Farley, and Lehmann's (1990) comprehensive meta-analysis on diffusion models of new products showed that past studies on average had a sample size of 14 product categories. Golder and Tellis's studies (1993, 1997) on market pioneering and sales takeoff had sample sizes of 35 and 31 product categories, respectively.

The sample derived from the above procedure enjoys several strengths. First, the sample does not suffer from survival bias. The reason is that we include any incumbent or entrant, large or small, surviving or dead, so long as it was the first to introduce the radical innovation. We are able to do so by referencing articles about the radical innovation written close to the time the innovation occurred, and not relying on self-reports by current participants in the industry. Second, the domain of our sample is international, because country of origin of the firm or the innovation is not a criterion for selection. Third, our sample covers an extensive time period, with introduction dates spanning close to 150 years. Fourth, all our data come from publicly available sources that are accessible to any interested party.

Measures

This section describes the measures for key variables: radical innovation, size, innovator, incumbent, time, and nationality.

Radical Innovation. In order to provide greater objectivity to the classification and rating of these innovations, we developed an index of radicalness of each innovation. Recall that our definition of a radical product innovation involves two dimensions: whether a new product (1) incorporates a substantially different core technology and (2) provides substantially higher customer benefits relative to the previous product generation in the category. We had raters rate the innovations on these two dimensions of radicalness. Each dimension involved a 9-point scale. For differences in core technology relative to the previous product generation, they had to rate each innovation on a scale ranging from 1 (Not at all different) to 9 (Substantially different). For superiority in user benefits relative to the previous product generation, they had to rate each innovation on a scale ranging from 1 (Not at all higher) to 9 (Substantially higher).

All three raters are knowledgeable of the history of innovation in the product classes studied. All three raters had published articles on innovation or new products in leading marketing journals, including the *Journal of Marketing Research*. Nevertheless, because we were studying a wide variety of innovations, for which even experts may not remember all the details, we gave the raters key information on each of the two dimensions (consumer benefits and technology) for each of the current innovations and its previous product generation. Appendix 1 provides the instructions to the raters. Two of the raters were also the authors of this paper.

Firm Size. A firm's size has many measures, the most common being number of employees, sales volume, or value of assets. Empirical research indicates that in the context of radical innovation, these alternate definitions of firm size provide similar results (Agarwal 1979a, b; Chandy and Tellis 1998; Child 1973). The most common measure of size in the innovation literature is a firm's employees (Cohen and Levin 1989; Pavitt, Robson, and Townsend 1987). This measure is theoretically appealing, since many of the problems of large firms (such as increased bureaucracy and inertia) are due to the increased need for coordination as a firm employs more people (Kimberly 1976). Hence we operationalize *firm size* as the number of employees in the firm.

To measure firm size, we determined the number of fulltime employees in the firm at the time the radical product innovation was commercialized (e.g., Cohen and Levin 1989; Pavitt, Robson, and Townsend 1987). We then defined a firm as being small if it employed less than 100 employees, medium if it employed between 100 and 2,499 employees, and large if it employed 2,500 or more employees (see Pavitt, Robson, and Townsend 1987). In our analysis, we use both a continuous measure of firm size, as well as the above categorical measure. As we note later, our results are robust to the cutoff value used to distinguish between small and medium firms in the categorical measure.

For publicly traded firms, we obtained size information from publications such as *Moody's Industrial Manual* (which extends back to the turn of the century) and the

Standard & Poor's manual. For privately held firms, we obtained the information from historical records such as company directories (e.g., the *Industrial Laboratories Directory*), contemporary journalistic accounts, biographies, and other individual sources (e.g., employee timesheets for 1880 from the Edison Electric Light Co.). For some small start-up firms, we were unable to nail down the precise number of fulltime employees at the time the firm commercialized the radical product innovation. However, we were in every case able to determine if the firm had fewer than 100 employees at that time.

From a data collection standpoint, information on the number of employees is more commonly available than that on the alternate measures. Nevertheless, to validate this measure of firm size, we also collected information on firm sales and assets in the year of introduction of the innovation for 27 of the innovating firms in our sample for which data were available. We converted the sales and asset information into 1980 U.S. dollars by multiplying the raw sales and assets figures by the appropriate exchange rate and inflation rate indices. We then correlated these standardized sales and assets variables with the number of employees in the relevant firms. The correlation between the number of employees in a firm and its standardized sales is .75 ($p < .001$), and that between employees and standardized assets is .73 ($p < .001$). Thus, in addition to theoretical support, our measure of size is also closely related to the alternate measures.

Innovator and Incumbent. As in Cooper and Schendel (1976) and Utterback (1994), we defined the *radical innovator* as the firm that first commercialized the radical innovation.[1] Following Golder and Tellis (1993, 1997), Gort and Klepper (1982), and Gort and Wall (1986), we defined the *introduction date* as the date of first commercialization of the radical innovation. To measure *incumbency*, we first identified the product generation that preceded the radical product innovation. Following Henderson (1993), Mitchell (1991), and Mitchell and Singh (1993), we then defined a firm as an *incumbent* if it manufactured or sold products that belonged to the previous product generation. We defined it as a new entrant if it did not. Six of the innovations in our sample fulfilled needs that were not met by any previous product. For example, no specific products fulfilled the needs later met by phone answering machines. In these cases, the "previous product generation" was defined as the service or technology by which the particular need was fulfilled prior to the introduction of the innovation (e.g., human answering service in the case of phone answering machines).

Time. To study trends in the incumbent's curse over time, we compared the profile of radical innovators before and after World War II. However, to detect continuous trends over time, we also used a continuous measure of time, starting with the earliest product in our sample, introduced in 1851. This year was coded as year 1, and every subsequent year was coded relative to this year (e.g., 1950 was coded as year 100, etc.).

When presenting the categorical analyses, we focus on the pre- and post-World War II period in particular since the World War II period saw the birth of many fundamental new technologies in the electronics, telecommunications, and computing fields (Sakudo and Shiba 1994; Teitelman 1994). These technologies

were first applied to civilian uses in the period after the war. World War II was also a major economic event that significantly altered the business environment of many countries. Many incumbents found their fortunes dramatically changed by the war, and a new generation of start-ups rose to commercialize the technologies developed during this period. Finally, separating pre-World War II innovations from post-World War II innovations splits our sample neatly based on recent and earlier technological breakthroughs. Products in the earlier sample generally represent breakthroughs in electrification, mechanization, and chemistry. Products in the later sample are largely based on breakthroughs in electronics and computing.

Nationality. We measured *nationality* as the country where the firm was headquartered at the time it introduced the radical innovation. In all but one of the innovations in our sample, the firms' development efforts leading to the radical innovation were based in the same country as that where the firms were headquartered.

Results

From the original set of 93 innovations, we were able to collect reliable information on each of the variables of interest for 64 innovations, which constitute the sample for our analysis (see Appendix 2). This section first presents bivariate categorical analyses of the dependent variable, and then multivariate analyses of the continuous variables.

Categorical Analysis

To get a better feel for the phenomenon, we first present bivariate categorical analyses of the key relationships. To do so, we categorize three of our continuous variables: radical innovation, time, and size. First, we classify the sample of 64 innovations as radical, if the average rating from all three raters on each dimension was equal to or more than 5 on the 9-point scale. Fifty-three innovations met this criterion. Second, we labeled firms with less than 100 employees as small, 100-2,499 as medium and 2,500 or more employees as large. Unfortunately, we had only six medium firms by this criterion. So we collapsed the class of small and medium firms into one group. Third, we categorize time as pre- and post-World War II, for reasons stated earlier. This section reports the characteristics of radical innovations on each of the key variables of interest.[2]

Role of Size and Incumbency. Recall that the incumbent's curse suggests that incumbents are much less likely than nonincumbents to introduce radical innovations. Table 2 shows that nonincumbents introduced 53 percent of the innovations while incumbents introduced 47 percent. The difference in proportions (δ) is not statistically significant (δ = 6 percent, $p > .40$). This result implies that incumbents may be as likely to introduce radical innovations as are nonincumbents. Thus, the overall results do not support the incumbent's curse.

Table 2. Radical Innovators by Incumbency Status

Nonincumbent	Incumbent
53%	47%

Our theoretical discussion suggests that large firms are *less* likely to introduce radical innovations than are small firms due to inertia and bureaucracy. To test this hypothesis, we classified radical innovations by firm size. Table 3 describes the percentage of radical innovations by firm size. Overall, small and medium firms introduced 58 percent of the innovations in the sample, while large firms introduced 42 percent of the innovations. The difference between these two proportions is statistically significant (δ = 30 percent, $p < .001$). This result seems to support the theory of the inertia and bureaucracy of large firms.

Table 3. Radical Innovators by Firm Size

Small and Medium	Large
58%	42%

A valid question at this point is how the combination of size and incumbency affects radical innovations. Table 4 shows a dramatic interaction effect of these two variables. Smaller nonincumbents are almost four times as likely to be radical innovators as large nonincumbents. On the other hand, large incumbents are close to twice as likely to be the radical innovators as are small and medium incumbents. Thus, size seems to favor incumbents and disfavor nonincumbents.

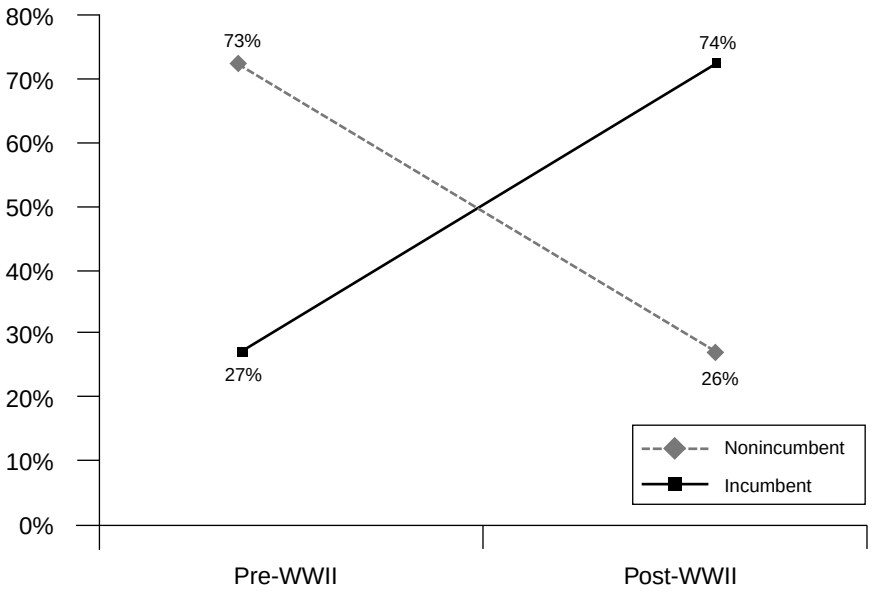
Table 4. Radical Innovators by Incumbency and Size

	Small and Medium	Large
Nonincumbent	42%	11%
Incumbent	17%	30%

Trends over Time. The previous results indicate that when analyzed separately, incumbents tend to introduce radical innovations at roughly the same proportion as nonincumbents. Has this pattern remained steady over time? We use the term *older* for pre-World War II innovations and *recent* for post-World War II innovations.

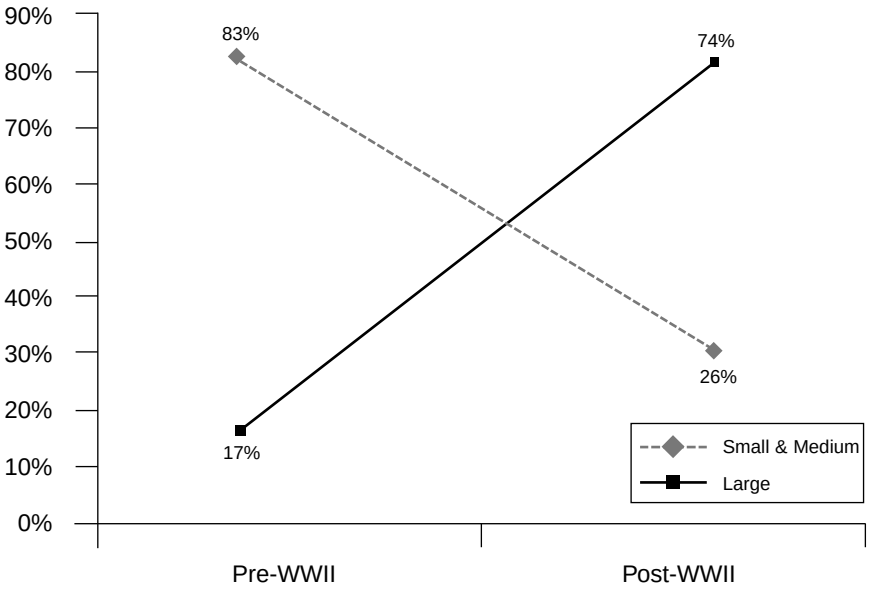
Figure 2 shows that the older innovations were introduced mostly by nonincumbents (73 percent), and much less by incumbents (δ = 47 percent, $p < .0001$) of the innovations. But a very different picture emerges when we focus on recent innovations. Incumbents significantly outnumbered nonincumbents for recent innovations (74 percent to 26 percent, δ = 48 percent, $p < .0001$). These results indicate that while the incumbent's curse may have been a problem in earlier times, it has not been in recent times.

Figure 2. Incumbency Status of Radical Innovators over Time



As with incumbency, the reversal over time also occurs for the size of innovators. Figure 3 shows that small and medium firms accounted for a majority (83 percent) of older innovations, relative to large firms (17 percent) (δ = 67 percent, $p < .0001$). The pattern changes dramatically in recent times, when smaller firms account for only 26 percent of the innovations, relative to 74 percent for large firms (δ = 48 percent, $p < .0001$).

Figure 3. Size of Radical Innovators over Time



These results suggest that small firms or nonincumbents were more radically innovative in an earlier time period, probably because of their nimbleness or lack of inertia relative to the complexity of prevailing technology. However, in recent times large firms and incumbents account for more radical innovations, probably because their large financial, technical, or market capabilities enable them to better master the complex technologies. A review of the historical evidence also brings to light an additional explanation for the innovativeness of incumbents and large firms in recent years. In the post-World War II period, large firms and incumbents instituted *organizational features* that better support radical innovation (Chandler 1956; Williamson 1975). These organizational features may make them willing to cannibalize their own past investments (Chandy and Tellis 1998). We cover this issue in greater depth in the subsequent discussion.

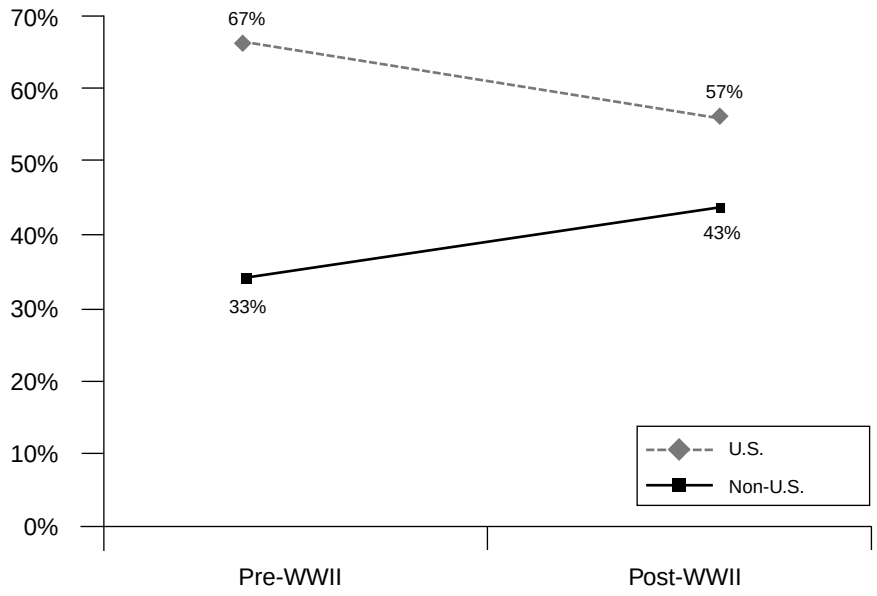
International Comparisons. What proportion of radical innovations come from U.S. firms? Table 5 shows that over 60 percent of the innovations were by U.S. firms (δ = 24 percent, $p < .001$). However, unlike the previous results, this proportion remains quite steady across time periods (Figure 4). Sixty-seven percent of the older innovations were from U.S. firms, compared to 57 percent of the recent innovations, but this difference is not significantly different from zero (δ = 10 percent, $p > .45$).

Table 5. Radical Innovators by Nationality

U.S.	Non-U.S.
62%	38%

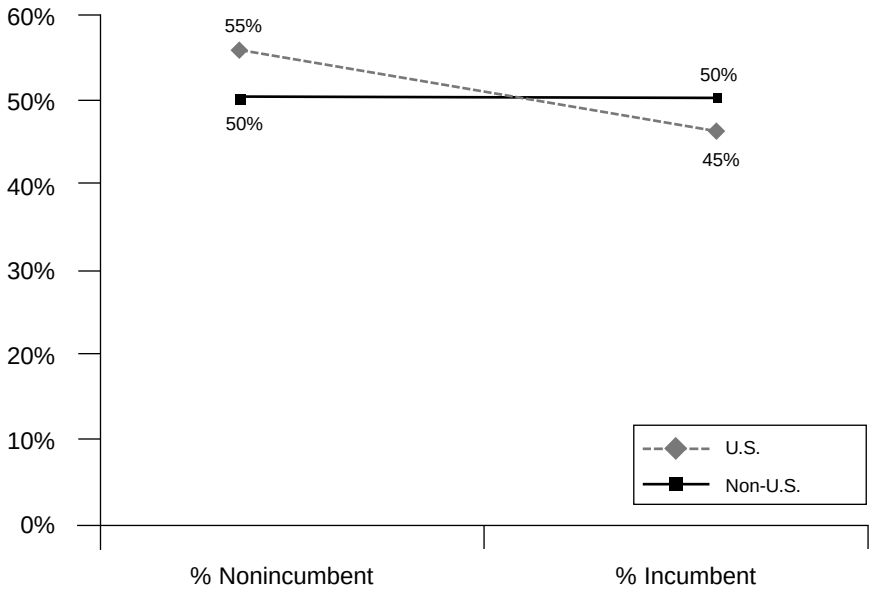
The major change across these two periods was the emergence of Japan as a source of innovation. While all but one of the older non-U.S. innovations were introduced by European firms, both Japanese and European firms are responsible for recent non-U.S. innovations. These results suggest that, in the product classes we study, the U.S. dominates, but does not exclusively control, the field of radical innovation. It also suggests no strong temporal patterns in U.S. innovativeness in these categories. Western European nations seem to have lost some ground in recent years to Japanese firms.

Figure 4. Nationality of Radical Innovators over Time



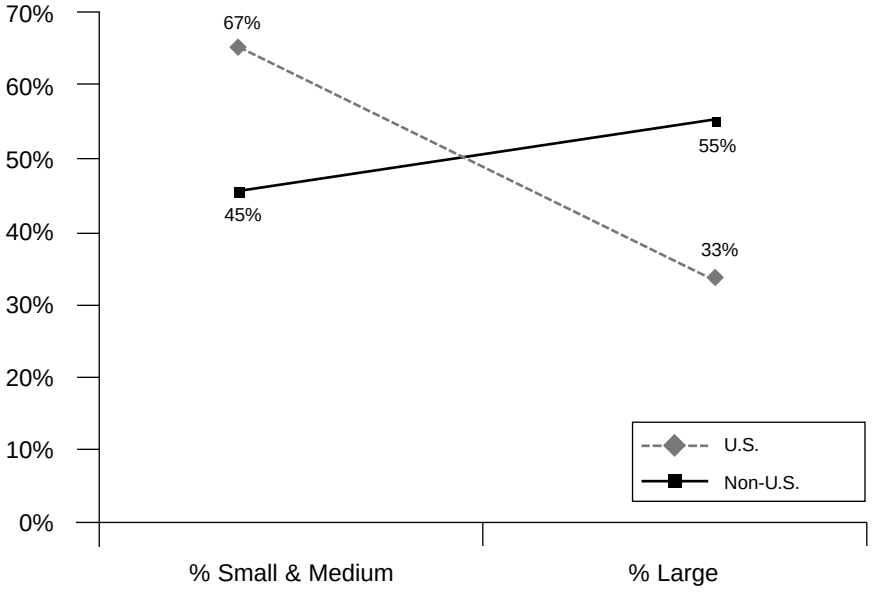
We had hypothesized that due to institutional factors (e.g., government policies, availability of venture capital) and cultural factors (e.g., attitudes toward entrepreneurship), U.S. innovations would be more likely to come from nonincumbent, small firms than would be the case with non-U.S. innovations. Figure 5 presents the results on incumbency among U.S. and non-U.S. innovators. Fifty-five percent of the U.S. innovations were introduced by nonincumbents, relative to 45 percent by incumbents, though this difference is not statistically significant (δ = 10 percent, $p > .29$). Non-U.S. innovations came from incumbent and nonincumbents in equal proportions (δ = 0 percent).

Figure 5. Radical Innovators by Incumbency Status and Country of Origin



An analysis of the size distribution of U.S. vs. non-U.S. innovators reveals similar patterns. Figure 6 shows that a majority of the U.S. innovations were introduced by small and medium firms relative to large firms (δ = 34 percent, $p < .001$). However, non-U.S. innovations came from small and medium firms relative to large firms in roughly equal proportions (δ = 10 percent, $p > .36$).

Figure 6. Radical Innovators by Size and Country of Origin



We also conducted a further analysis of the trends over time within the sample of radical innovations introduced by U.S. firms (n = 33). This analysis indicates that the sources of U.S. radical innovations also changed dramatically in the post-World War II period. The older U.S. innovations tended to come from smaller firms and nonincumbents, while the more recent U.S. innovations tend to come from large firms and incumbents, thus paralleling the results for the overall sample. However, due to the limited sample size in this analysis, we do not present quantitative results or significance levels (cf. Frank and Althoen 1994).

The results presented so far were based on a bivariate analysis of radical innovations by categorized independent variables. The above results do not distinguish between highly radical and less radical innovations, nor do they explain the variation of the relationship over the range of time and firm size. So we next present multivariate results from our full sample of 64 innovations, thus utilizing the full range of information available in our sample.

Multivariate Results

To understand the extent to which our key variables (Incumbency, Size, Time, and Nationality) explain the level of radicalness of the innovations, we estimate the following regression equation:

(1) **Radicalness of Innovation** = $\beta_0 + \beta_1$ **Incumbent** + β_2 **Large** + β_3 **Time** + β_4 **US** + β_5 (**Time x Incumbent**) + β_6 (**Time x Large**) + β_7 (**Time x US**) + ε

Where:

Radicalness of Innovation is a variable = $\Sigma_{i=1 \text{ to } 3}$ $(\text{Technology Rating})_i$ + $\Sigma_{i=1 \text{ to } 3}$ $(\text{Benefits Rating})_i$, and:

$(\text{Technology Rating})_i$ is rater i's rating of the extent to which the core technology in the innovation is substantially different from that used in the previous product generation, and

$(\text{Benefits Rating})_i$ is rater i's rating of the extent to which the product provides substantially superior benefits relative to the previous product generation;

Incumbent, Large, and **US** are dummy variables defined as above; **Time** is a continuous variable ranging from 1 (for the year 1851) to 148 (for the year 1998); βs are coefficients to be estimated, and ε is a vector of errors assumed to be I.I.D. normal.

The choice and specification of independent variables follows from our theoretical discussion. To test the extent to which our results are robust to differing operationalizations of firm size, we also estimate the following regression equation:

(2) **Radicalness of Innovation** = $\gamma_0 + \gamma_1$ **Incumbent** + γ_2 **Employees** + γ_3 **Time** + γ_4 **US** + γ_5 (**Time x Incumbent**) + γ_6 (**Time x Employees**) + γ_7 (**Time x US**) + ν

where, **Employees** is the actual number of fulltime employees in the company in the year in which it introduced the innovation, γs are coefficients to be estimated, ν is a vector of errors assumed to be I.I.D. normal, and all other variables are defined as before.

Table 6 presents the stepwise results of estimating Equation 1. The regression results, as well as the tests of bivariate correlations, are generally consistent with the results of the categorical analyses. In particular, the regression analysis indicates that the main effect of incumbents (model 1) and large firms (model 3) on radical innovations is negative.

Table 6. Regression Results
Dependent Variable: Radicalness of Innovation

	Model 1 β (t value)	Model 2 β (t value)	Model 3 β (t value)	Model 4 β (t value)	Model 5 β (t value)
Incumbent	-.21 (1.7)	-.41 (1.3)	-.19 (.6)	-.31 (1.0)	-.27 (.4)
Large	-	-	-.85 (1.6)	-1.05 (1.9)	-
Employees	-	-	-	-	-4.06 (2.1)
U.S.	-	-	-	-.51 (1.7)	-1.28 (1.0)
Year	-	-.47 (2.7)	-.56 (3.2)	-.92 (3.6)	-.96 (1.5)
Year X Incumbent	-	.43 (1.1)	0.00 (0.0)	.14 (.3)	.29 (.3)
Year X Large	-	-	1.17 (2.0)	1.45 (2.3)	-
Year X U.S.	-	-	-	.59 (1.9)	1.42 (1.3)
Year X Employee	-	-	-	-	4.37 (2.2)
Adjusted R^2	3%	12%	16%	19%	5%

However, in the regression with all independent variables (model 4), neither the main effect of incumbency nor its interaction with time are significantly different from zero. This result indicates that innovations introduced by incumbent firms *are no less radical* than those introduced by nonincumbents. (Incumbency and size are positively related, so the difference in these results from the bivariate case may also be due to the collinearity between incumbency and size.) The results also indicate a strong interaction between firm size and time, similar to that in the categorical analysis. The results indicate that while larger firms have introduced less radical innovations, in recent years the trend has reversed. Indeed, the size and sign of the standardized coefficient of this interaction is such that it more than cancels out the negative effect of size on radicalness. Thus in recent years, innovations introduced by large firms are *more radical* than those introduced by smaller firms. Similarly there is a strong interaction of time x US. The coefficient indicates that in recent years, innovations introduced by U.S. firms are more radical than those introduced by non-U.S. firms.

For the above analysis we used a truncated measure of size. Table 6 (model 5) also presents the results using a continuous measure of size, number of employees. Note

that the pattern of results is very similar across the two measures. This indicates that the effects of size are strong and robust. We observe them in the categorical analyses, in the bivariate regression, and over two alternate measures in the multivariate analysis.

Additional Analyses

Our research design and results raise three issues that merit further discussion: relevant population, definition of firm size, and definition of radical innovator.

Relevant Population

When analyzing the sources of radical innovations we contrasted innovative large firms and incumbents to innovative small firms and outsiders, respectively. However, to fully interpret these figures, one needs to also contrast the proportion of small, medium, and large firms in the sample with the proportion of small, medium, and large firms in the overall manufacturing economy. Similarly, one needs to contrast the proportion of incumbents and outsiders in the sample with the relevant proportions in the overall manufacturing economy. For example, our categorical analyses indicate that small, medium, and large firms account for 47 percent, 11 percent, and 42 percent, respectively of the radical innovations in the sample. But if small, medium, and large firms also account for 47 percent, 11 percent, and 42 percent of the manufacturing economy, then our results would only indicate that firms in each size class contribute radical innovations in a number proportionate to their number in the population.

To contrast these proportions, we sought to collect data on the number of small, medium, and large firms in the manufacturing economy. The U.S. Census Bureau has reported this information as part of its *Census of Manufactures* starting in 1909. Thus we were able to obtain the information for all U.S. innovations introduced after 1909. We were also able to obtain similar information on seven out of the eight Japanese innovations, and one each of the Dutch and German innovations (through their respective *Census of Manufactures*).

An analysis of the U.S. data indicates that the proportion of large firms (i.e., those with 2,500 or more employees) never exceeded .22 percent of the total number of firms in the U.S. manufacturing economy. The proportion of large firms in the U.S. manufacturing economy ranged from a high of .22 percent (in 1967) to a low of .04 percent (in 1909). The proportion of medium (i.e., 100 - 2,499 employees) firms in the U.S. manufacturing economy ranged from a high of 10.82 percent (in 1972) to a low of 5.27 percent (in 1909), while the proportion of small firms ranged from a high of 94.69 percent (in 1909) to a low of 88.99 percent (in 1972). Thus simply from a probabilistic sense, medium and (especially) small firms would be expected to contribute a *much* larger number of innovations than large firms. But this is not the case. Large firms account for a substantially larger proportion of radical innovations relative to their number in the economy. The data from the non-U.S. sources also provide similarly large contrasts.

A similar argument can be made for the proportion of incumbent firms in the economy, relative to the proportion of innovations accounted for by them. The number of incumbent firms in any particular product class is likely to be many times smaller than the number of nonincumbents in the economy, simply because

the economy consists of many such product classes. Yet incumbents account for close to half the number of radical innovations overall in the product classes studied here, and about three-fourths of the radical innovations introduced after World War II. As with large firms, incumbents account for a disproportionately larger number of radical innovations relative to their number in the economy.

Definition of Firm Size

In the categorical analyses, we defined a firm as small if it had less than 100 employees, medium if it had between 100 and 2,499 employees, and large if it had 2,500 or more employees. What happens if we select different cutoff points for firm size? Table 7 presents the results of a sensitivity analysis reflecting different cutoff values for small and medium firms. The cutoff values are based on the categories used by the U.S. Census Bureau in classifying the size of firms. Since the "2,500 or more employees" category is already the U.S. Census Bureau's category of largest firms in the manufacturing economy, we do not vary our definition of large firms.

Table 7. Percentage of Innovations by Small and Medium Firms, Based on Definition of Small Firm

Definition of Small Firm	% Small	% Medium
>20 employees	36%	23%
>100 employees	47%	11%
>500 employees	49%	9%
>1,000 employees	55%	4%
>2,500 employees	58%	0%

As Table 7 indicates, there is a sharp decrease in the proportion of innovations from medium firms as the lower cutoff for medium firms increases from 20 employees to 100 employees. Beyond this point, the decreases are much less steep. Thus the cutoff point of 100 employees captures most of the innovative small firms in our sample.

Definition of Radical Innovator

Recall that we define a radical innovator as the firm that *first* commercialized a radical product innovation. This definition excludes other early entrants in the product category, even though these entrants may have introduced their products not long after the first entrant. What would the size and incumbency profile of such early entrants be?

Several researchers have argued that incumbents would be the most likely early entrants (e.g., Ali 1994; Conner 1988; also see Nault and Vandenbosch 1996).

They suggest that due to fears of cannibalization, many established firms will refrain from commercializing their innovations as long as possible—until outsiders introduce the radically innovative products to the market. Thus, such firms would not seek to be the first to commercialize the radically new technology. But once products based on the new technology have already been introduced to the market, the firms would rush in with their own equivalent products. They would capitalize on their marketing and technology resources to then take full advantage of their fast-follower status.

If the above reasoning holds, then our results would only represent the tip of the iceberg in terms of the innovation performance of large firms and incumbents. Once a firm commercialized a radically new product, many large firms and incumbents would likely have moved in with similar products. Thus large firms and incumbents may have been even more “innovative” than our results indicate.

Discussion

In this sample of consumer durables and office product classes, we find that small firms and nonincumbents are slightly more likely to introduce radical product innovations than large firms and incumbents. Yet in recent years the pattern has changed dramatically. Recently, large firms and incumbents are significantly *more likely* to introduce radical innovations than small firms and nonincumbents. Further, the innovations introduced by recent large firms and incumbents are *no less radical* than those introduced by small firms and nonincumbents. Thus, our results indicate that the incumbent's curse may apply, but to an earlier economic period. The curse may apply even less to countries outside the U.S. In our limited sample, while the U.S. does account for a simple majority of radical innovations, it does not account for an overwhelming proportion of them. Also, its share of radical innovations has not changed much over time periods.

In the hope of motivating further research on some of the counterintuitive findings from this study, we highlight two important issues raised by this study: lessons from large or incumbent innovators, and opportunity for nonincumbents and small firms. The factors we highlight below could also provide directions to current managers in similar innovation contexts. Because we do not have precise measures of these factors, this discussion is exploratory in nature.

Lessons from Large or Incumbent Innovators

Contrary to conventional wisdom, our research indicates that today's incumbents and large firms do account for many radical innovations, especially after World War II. This finding dovetails with recent research that suggests that a considerable proportion of dominant firms in today's high-tech industries are willing to cannibalize their own past investments to introduce radical product innovations (Chandy and Tellis 1998).

Yet not all incumbents and large firms are able or willing to make the transition to the new technology that is embodied in a radical product innovation. For example, SSIH, a dominant mechanical watch producer, did not introduce quartz watches until late in their life cycle. By that time its market position had been considerably weakened (Glasmeier 1991). However, Hattori-Seiko, another dominant producer of mechanical watches, was the first firm to introduce the analog quartz watch. Still another incumbent, the Hamilton Company, was the first to introduce the digital quartz watch. Why do some dominant firms maintain their innovative vigor despite the supposed liabilities of size and incumbency? This question has strong implications for large and incumbent firms that are currently contemplating radical innovations. While we do not have conclusive evidence on this question, our historical research did suggest two possible causes: dynamic organizational climates and strong technological capability. We elaborate on these two points below.

Dynamic Organizational Climates. One reason for the innovation performance of some large, incumbent firms may be that such firms have organizational climates

that resemble those of small firms. After World War II, fundamental changes occurred in the structure of many large, incumbent firms (Chandler 1990). Many large firms created autonomous business units with significant authority over their lines of business, and separate profit and loss responsibilities (Chandler 1956; Williamson 1975). The benefits of this organizational structure quickly became popular, so that by the mid-1950s, the practice of decentralization became widespread among large American corporations (Chandler 1956, p.111). As discussed earlier, growth in size and complexity can lead to bureaucratic inertia that dampens the innovativeness of firms. In contrast, decentralization leads to smaller, autonomous organizational units that allow the large firm to respond to and create technological innovations while maintaining their resource advantages.

Decentralization may also have fostered internal competition: incumbent and non-incumbent business units *within* a large incumbent that compete for markets (Chandy and Tellis 1998; Forrester 1965). As a result, even though a particular business unit may have a strong stake in the existing product category, other business units within the incumbent firm, who do not derive many rents from the existing products, may not be as committed to these products. These latter business units also do not have the established routines that may constrain the actions of the incumbent units. They are therefore quite likely to support radical product innovations, since these products represent considerable opportunity, but relatively little threat to their existing lines of business. The firm as a whole is thus supportive of radical product innovations, despite its incumbency, and even in the absence of external competitors.

The history of the analog quartz watch provides a good illustration of the effects of autonomy and internal competition on radical innovation. The first analog quartz watch was commercialized by Hattori-Seiko in 1969. This product resulted from a "technology contest" between the company's Suwa Seikosha and Daina Seikosha divisions (*Business Week* 1978). The organization was structured such that these two divisions maintained separate research, design, and manufacturing facilities. Hattori's central office informed both divisions of its anticipated product needs. These divisions then independently developed product prototypes from which Hattori selected models to be mass-produced for the market (Hoff 1985).

Technological Capability. Our theoretical discussion highlighted the role of technological capabilities in influencing radical innovation by large firms. Incumbent firms with strong technological capability are likely to become aware of scientific breakthroughs at an early stage, and are in a position to pursue those that could lead to radical product innovations. The General Electric Company's historical emphasis on basic research provides a rich illustration of the role of technological capability in radical innovation.

For example, the General Electric Company established its Research Laboratory in 1900 (Birr 1957; Bright 1949). Scientists at the laboratory published actively in leading scientific journals. The lab was insulated from immediate business demands, and staffed by people with advanced scientific training (Reich 1985). Willis Whitney, its founding director, was elected to serve as president of the American Chemical Society in 1909, and Irving Langmuir, a scientist at GE, won

the 1932 Nobel Prize for chemistry for work conducted at the firm between 1912 and 1915 (Brown and Weeks 1952; Wise 1985). The research conducted at the laboratory played an important role in the company's ability to develop and commercialize fluorescent lamps even while it was the dominant player in incandescent lamps. Few other small firms at that time had the technological capability to introduce these new products.

Note that an emphasis on basic research will yield meager payoffs to firms that do not also have an organizational setup that encourages the development and marketing of commercially viable innovations. While basic research may provide a source of technology ideas in the early stages of radical product development, a dynamic organizational climate is likely to be critical in the refinement and commercialization of radically new products.

Opportunity for Nonincumbents and Smaller Firms

Successful development of a radical innovation today can require huge expenditures in R&D. The reason is that advances in technology have made new products far more complex than they were a century ago, or even a few decades ago. At the same time, the noise level from competing advertising and promotion for myriad old and new brands raises a formidable barrier for any new entrant. Thus the image of the tinkerer-innovator fashioning radical innovations in his small garage may not be always true. However, our research indicates even in these noisy markets small firms or nonincumbents do introduce radical innovation.

How can a firm with relatively few resources succeed in a process that presumably requires large outlays in research and development? The case histories of innovative small and medium firms in our sample provide some clues.

One option is to make use of spillovers from research conducted at other, resource-rich firms. Some small firms focus on the development part of the research and development process, relying on off-the-shelf components from other industries to introduce technologies that are radically new in a different industry. For example, the first personal computer was developed and introduced by Ed Roberts, a practicing physician, and founder of MITS, using many components (such as integrated circuits) that were the result of basic research by other companies. However, such a business model leaves the firm vulnerable to imitators. Success may be hard to sustain unless there is a steady stream of ever-improving off-the-shelf components in the industry, or the product takes off quickly enough to provide the firm with the resources to build its own technological base.

A different (and perhaps more sustainable) innovation model is that which the Haloid Corporation followed in the steps leading to the introduction of the plain paper copier (see Dessauer 1971; *Fortune* 1949; Jewekes, Sawers, and Stillerman 1969). The idea for electrostatic copying came from Chester Carlson, an individual inventor, who also developed a primitive prototype of the product. After failing to interest any of the large incumbents in the photographic copier business (the previous product generation), Carlson finally succeeded in obtaining the support of the Battelle Memorial Institute, then the world's largest nonprofit research orga-

nization. The managers at the Haloid Corporation, a medium-sized incumbent in the photographic copier industry, saw a description of the electrostatic technology in the April 1945 issue of *Kodak's Monthly Abstract Bulletin*. In 1946, after other large incumbents (including Kodak) had turned down the opportunity to license the technology and participate in its development, Haloid signed a contract with Battelle to partly fund further development of the technology. Though Haloid's $25,000 investment represented a significant proportion of its $138,000 net income in 1947, this and other subsequent contributions by Haloid were insufficient to fully fund the development of a commercially viable copier. It was through Battelle's strength in basic research, and in 1948, a $120,000 research grant from the United States Signal Corps, that the commercial Xerographic copier became possible. Thus Haloid, a medium-sized incumbent with limited technological capability, relied on the resources of a strong research organization and funding from the federal government to develop its radically new product. Over time, Haloid (which changed its name to Xerox after the new product became an important revenue source) bought many of the key Xerography patents from Battelle. This patent protection, together with further research on its own part, allowed the firm to protect its market position relative to later entrants.

In summary, small nonincumbents have at least two options in developing and introducing radical product innovations: (1) use research spillovers from more resource-rich firms, and (2) actively partner with organizations with technological capabilities and financial resources that they do not have themselves. Of these two options, the second may be a less imitable and more sustainable option in many industries.

Limitations

Though the historical method allows for unique and fairly objective insights on radical innovation, it also imposes constraints on the scope of our study. These limitations highlight the need for additional research on the topic. First, historical analysis is highly labor-intensive. Resource constraints caused us to restrict our sample to a small number of innovations (64) in a limited number of categories (49) in only two classes of goods, office products and consumer durables. For example, the role of marketing, financial, and technical capabilities may differ across product classes, and the innovation performance of incumbents may vary accordingly. Further, our list of innovations does not exhaustively cover all the significant innovations in these two product classes. Therefore, though our sample size is much larger than that of past historical research on radical innovation, inferences regarding product classes other than those we study here should be made with caution. Second, our study focuses upon only relatively successful innovations. Including failed or less successful innovations in the sample may lead to additional insights. Third, we have information on only external characteristics of the firm, such as incumbency, size, and country of operation.[3] Further research could gather information on internal characteristics of such firms to test some of the organizational hypotheses suggested above.

Conclusion

Inactive. Incompetent. Arrogant. These are some of the terms currently used to describe the behavior of incumbent and large firms with respect to radical product innovation (see Ghemawat 1991; Henderson 1993; Utterback 1994). Many academics and practitioners accept such terms as appropriate descriptors of these firms. Radical innovation is likened to a game of chutes and ladders, where incumbents abruptly lose their positions to upstart outsiders (see Utterback 1994, p.189).

But do these terms and analogies truly reflect reality? Events where the mighty are humbled and the little guy finishes first are likely to be more eye-catching than are those where the mighty remain mighty. Unless one starts with a large, predetermined sample, one may miss the latter, less salient events. For this reason we researched a relatively large cross-section of radical innovations that were sampled on certain explicit criteria.

Our research on innovations in the consumer durables and office product categories suggests that incumbents or large firms are not necessarily doomed to obsolescence by nimble outsiders. In particular, our research leads to the following main conclusions regarding radical innovations in these industries:

- Over a 150-year period, small firms and nonincumbents introduced slightly more radical product innovations than large firms and incumbents.
- However, the sources of radical product innovations changed substantially after World War II. Large firms and incumbents introduced a majority of radical product innovations over this time period. Thus, the incumbent's curse is less prevalent in recent times.
- The U.S. accounts for close to two-thirds of radical product innovations in the sample, while Western Europe accounts for most of the remaining. Japan accounts for only a few innovations, but those have been entirely in recent years. The distribution of radical innovations between the U.S. and other nations has remained steady over time.
- Small firms and outsiders account for many more innovations in the U.S. than they do in other countries. Thus, the incumbent's curse is less prevalent in Western Europe and Japan than in the U.S.

Dynamic organizational structures and strong technological capability may be factors that can keep large, incumbent organizations nimble and innovative. But many managers and academics have tended to focus on inertia-prone incumbents (Henderson and Clark 1990; Henderson 1993; Ghemawat 1991; Scherer 1980; Utterback 1994; for recent exceptions, see Christensen 1997; Tushman and O'Reilly 1997). In focusing on the Remingtons and Underwoods of the world, let us not forget the examples of GE (in fluorescent lamps), Phillips (in CD players), and Seiko (in quartz watches). Despite their large size and incumbency in the

incandescent lamp, tape recorder, and mechanical watch industries, respectively, these firms were the first to introduce radical innovations that changed the landscapes of these very industries. Perhaps the incumbent's curse is not as inevitable as it seems.

Appendix 1. Instructions to Raters

Introduction:

A radical product innovation is a new product that is (1) based on a substantially new core technology, and (2) provides substantially higher benefits to customers relative to the previous product generation. The term "higher benefits" in the above definition includes both greater need fulfillment and lower costs to the customer.

Attached is a list of innovations in the consumer durables and office products industries. The table lists each innovation as well as the previous product generation. The table also includes some comments on the technology used in the innovation and the benefits that it provided relative to the previous product generation.

Please rate each innovation listed in the table on the above two dimensions.

Thank you for your help.

Category	Innovation	Previous product generation	Comments	Substantially different core technology?	Substantially higher customer benefits?
				1= Not at all different 9= Substantially different	1= Not at all higher 9= Substantially higher

Appendix 2. Full List of Significant Innovations in Sample

Radical product innovation	First commercialized by	Year of commercialization
Air conditioner	Buffalo Forge Company	1902
AM radio	Wireless Telegraph & Signal Co.	1897
Analog answering machine	American Telegraphone Co.	1903
Analog quartz watch	Seiko	1969
Autofocus color celluloid roll camera	Konishiroku Photo Industry	1977
B&W celluloid roll camera	Eastman Dry Plate & Film Co.	1889
Ball point pen	Eterpen Co.	1943
Camcorder	Sony	1983
Cassette tape player	Phillips	1964
CD player	Phillips & Sony	1979
Cellular phone	Motorola	1983
Color celluloid roll camera	Lumiere Brothers	1907
Desktop computer	MITS	1975
Digital answering machine	Sharp	1988
Digital camera	Sony	1983
Digital high definition television	Panasonic	1998
Digital quartz watch	Hamilton Co.	1972
Digital video disc (DVD) player	Toshiba	1997
Disposable shaver	Bic Corp.	1975
Dot-matrix printer	Remington Rand	1953
Dry ink (electrostatic) copier	Haloid Co.	1951
Electric blanket	General Electric	1936
Electric blender	Waring Blendor Co.	1937
Electric can opener	Udico Corporation	1956
Electric clothes washer	Hurley Machine Co.	1908
Electric dishwasher	Willard and Forrest Walker	1913
Electric fan	Crocker & Curtis Co.	1882
Electric garbage disposer	General Electric	1934
Electric percolator	Landers, Frary, & Clark	1908
Electric shaver	Schick Inc.	1931
Electric toaster	General Electric	1908
Electric typewriter	Blickensderfer Co.	1902
Electrochemical fax	Caselli	1865
Electronic black & white TV	Allen B. Dumont Laboratories	1939
Electronic color TV	RCA	1954

Radical product innovation	First commercialized by	Year of commercialization
Electronic desktop calculator	Sharp	1964
Electronic pocket calculator	Bowmar	1971
Electronic watch	Bulova	1960
Fluorescent lamp	General Electric	1938
FM radio	General Electric	1937
Incandescent vacuum lamp	Edison Electric Light Co.	1880
Instant camera	Dubroni	1864
Internal combustion automobile (petrol)	Carl Benz	1888
Laptop computer	Tandy Corp.	1983
Laser disc player	Phillips	1978
Laser printer	IBM	1976
Magnetic tape player (reel-to-reel)	AEG	1934
Mechanical B&W TV	Television Ltd.	1930
Mechanical color TV	CBS-Columbia	1951
Mechanical dishwasher	Josephine Cochrane	1889
Mechanical refrigerator	John Gorrie	1851
Mechanical typewriter	Sholes/Densmore	1872
Mechanical vacuum cleaner	Vacuum Cleaning Co.	1901
Microwave oven	Raytheon	1953
Mini-disc player	Sony	1992
Palm computer	Amstrad	1993
Phone set with cord	Bell Telephone Co.	1876
Phonograph Edison Speaking	Phonograph Co.	1878
Portable computer	Osborne Computer	1981
Safety shaver with disposable blades	American Safety Razor Co.	1903
Single-player video game	Nutting Associates	1971
Photoelectric scanning fax	Arthur Korn	1907
VCR	Ampex Corp.	1956
Voice mail	ECS	1980

Notes

1. Thus this definition excludes all firms that commercialized the innovation after the first firm. As we note in the Additional Analysis section, relaxing this definition to include later entrants makes our results even stronger.

2. We also conducted the same analyses using the full list of 64 significant innovations. The key results from this analysis are consistent with those presented in this paper.

3. We also checked if innovations introduced by incumbents and large firms were the result of their acquisitions of innovative small firms and nonincumbents. We found that such acquisition-based innovations are rare in our sample. We further checked if, conversely, innovations introduced by nonincumbents and small firms were the result of technology developed within incumbents and large firms, but commercialized by nonincumbents and small firms. Such innovations are also rare in our sample.

References

Acs, Zoltan J., and David B. Audretsch (1991), *Innovation and Technological Change: An International Comparison.* Ann Arbor, MI: University of Michigan Press.

Agarwal, N. C. (1979a), "Nature of Size-Structure Relationship: Some Further Evidence." *Human Relations* 32 (6), 441-50.

_____ (1979b), "On the Interchangeability of Size Measures." *Academy of Management Journal* 22 (2), 404-9.

Ali, A. (1994), "Pioneering Versus Incremental Innovation: Review and Research Propositions." *Journal of Product Innovation Management* 11 (1), 46-61.

Arrow, Kenneth (1962), "Economic Welfare and the Allocation of Resources for Invention." In *The Rate and Direction of Economic Activity,* Universities - National Bureau Committee for Economic Research. Princeton, NJ: Princeton University Press, 609-25.

Barr, Pamela S., J. L. Stimpert, and Anne S. Huff (1992), "Cognitive Change, Strategic Action, and Organizational Renewal." *Strategic Management Journal* 13 (Summer Special Issue), 15-36.

Bauer, R. A. (1960), "Consumer Behavior as Risk Taking." In *Dynamic Marketing for a Changing World,* ed. R. S. Hancock. Chicago: American Marketing Association, 389-98.

Bilby, Kenneth (1986), *The General: David Sarnoff and the Rise of the Communications Industry.* New York: Harper and Row.

Birr, Kendall (1957), *Pioneering in Industrial Research: The Story of the General Electric Research Laboratory*. Washington, DC: Public Affairs Press.

Blau, Peter M., and Richard A. Schoenherr (1971), *The Structure of Organizations.* New York: Basic Books.

Bowers, Brian (1982), *A History of Electric Light & Power.* New York: P. Peregrinus in association with the Science Museum.

Bright, Arthur A. (1949), *The Electric-Lamp Industry: Technological Change and Economic Development from 1800 to 1947.* New York: Macmillan Co.

Brown, Charles A., and Mary E. Weeks (*1952), A History of the American Chemical Society*. Washington, DC: American Chemical Society.

Business Times (1996), "When Being Efficient Is Not Enough" (June 7), 9.

Business Week (1978), "K. Hattori's Blend of Internal Competition" (June 5), 90.

Caravatti, Marie-Louise (1992), "Why the United States Must Do More Process R&D." *Research and Technology Management* (September-October), 8-9.

Chandler, Alfred D. (1956), "Management Decentralization: An Historical Analysis." *Business History Review* 30 (June), 111-74.

_____ (1990), *Scale and Scope.* Cambridge, MA: Belknap Press.

Chandy, Rajesh, and Gerard Tellis (1998), "Organizing for Radical Product Innovation: The Overlooked Role of Willingness to Cannibalize." *Journal of Marketing Research* 35 (November), 474-87.

Child, John (1973), "Predicting and Understanding Organization Structure." *Administrative Science Quarterly* 18 (2),168-85.

Christensen, Clayton (1993), "The Rigid Disk Drive Industry: A History of Commercial and Technological Turbulence." *Business History Review* 67 (Winter), 531-88.

_____ (1997), *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.* Boston: Harvard Business School Press.

Cohen, Wesley (1995), "Empirical Studies of Innovative Activity." In *Handbook of the Economics of Innovation and Technological Change*, ed. Paul Stoneman. Cambridge, MA: Blackwell.

_____ , and Richard C. Levin (1989), "Empirical Studies of Innovation and Market Structure." In *Handbook of Industrial Organization*, Vol. 2, eds. R. Schmalensee and R. D. Willig. New York: Elsevier Science Publishers.

Comanor, W. S. (1967), "Market Structure, Product Differentiation, and Industrial Research." *Quarterly Journal of Economics* 81 (4), 639-57.

Conner, Kathleen (1988), "Strategies for Product Cannibalism." *Strategic Management Journal* 9 (Summer), 9-27.

Cook, Rosamond (1922), *Sewing Machines*. Preoria, IL: The Manual Arts Press.

Cooper, Arnold, and Dan Schendel (1976), "Strategic Responses to Technological Threats." *Business Horizons* 19 (February), 61-9.

_____ , and Clayton Smith (1992), "How Established Firms Respond to Threatening Technologies." *Academy of Management Executive* 6 (2), 55-70.

Cooper, Grace Rogers (1976), *The Sewing Machine: Its Invention and Development*. Washington, DC: Smithsonian Institution Press.

Deshpandé, Rohit, John U. Farley, and Frederick Webster (1996), "Corporate Culture, Customer Orientation, and Innovativeness in Japanese Firms: A Quadrad Analysis." *Journal of Marketing* 57 (January), 23-38.

Dessauer, John H. (1971), *My Years With Xerox: The Billions Nobody Wanted.* Garden City, NY: Doubleday and Company, Inc.

Ettlie, J., and A. H. Rubenstein (1987), "Firm Size and Product Innovation." *Journal of Product Innovation Management* 4 (1), 89-108.

Fitzroy, Felix R., and Kornelius Kraft (1991), "Firm Size, Growth, and Innovation: Some Evidence from West Germany." In *Innovation and Technological Change: An International Comparison*, eds. Zoltan J. Acs and David B. Audretsch. New York: Harvester Wheatsheaf.

Folkes, Valerie S. (1988), "The Availability Heuristic and Perceived Risk." *Journal of Consumer Research* 15 (June), 13-23.

Forrester, Jay W. (1965), "A New Corporate Design." *Sloan Management Review* 7 (1) (Fall), 5-17.

Fortune (1949), "Printing with Powders: A Process Named Xerography Puts Static Electricity to Work in the Graphic Arts." (June), 113-22.

Foster, R. (1986), *Innovation: The Attacker's Advantage*. New York: Summit Books.

Frank, Harry, and Steven C. Althoen (1994), *Statistics: Concepts and Applications.* New York: Cambridge University Press.

Galbraith, J. K. (1968), *The New Industrial State.* New York: Hamish Hamilton.

Gatignon, Hubert, and Jean-Marc Xuereb (1997), "Strategic Orientation of the Firm and New Product Performance." *Journal of Marketing Research* 34 (February), 77-90.

Ghemawat, Pankaj (1991), "Market Incumbency and Technological Inertia." *Marketing Science* 10 (Spring), 161-71.

Glasmeier, Amy (1991), "Technological Discontinuities and Flexible Production Networks: The Case of Switzerland and the World Watch Industry." *Research Policy* 20 (October), 469-85.

Golder, Peter N., and Gerard J. Tellis (1993), "Pioneer Advantage: Marketing Logic or Marketing Legend?" *Journal of Marketing Research* 30 (May), 158-70.

_____ , and _____ (1997), "Will It Ever Fly? Modeling the Takeoff of Really New Consumer Durables." *Marketing Science* 16 (3), 256-70.

Gort, Michael, and Steven Klepper (1982), "Time Paths in the Diffusion of Product Innovations." *The Economic Journal* 92 (September), 630-53.

_____ , and Richard A. Wall (1986), "The Evolution of Technologies and Investment in Innovation." *The Economic Journal* 96 (September), 741-57.

Gould, Jack (1959), "Tinted Television." *New York Times* (July 14), X13.

Hannan, M. T., and J. Freeman (1977), "The Population Ecology of Organizations." *American Journal of Sociology* 82 (5), 929-64.

Henderson, Rebecca (1993), "Underinvestment and Incompetence as Responses to Radical Innovation: Evidence from the Photolithographic Alignment Equipment Industry." *RAND Journal of Economics* 24 (2) (Summer), 248-71.

Henderson, Rebecca, and Kim B. Clark (1990), "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms." *Administrative Science Quarterly* 35 (January), 9-30.

Hiltzik, Michael (1999), *Dealers of Lightning: Xerox PARC and the Dawn of the Computer Age.* New York: Harper Collins.

Hoff, Edward J. (1985), *Hattori-Seiko and the World Watch Industry in 1980,* Harvard Business School Case # 9-385-300.

Imai, Ken-ichi (1990), "Patterns of Innovation and Entrepreneurship in Japan." In *Evolving Technology and Market Structure: Studies in Schumpeterian Economics,* eds. Arnold Heertje and Mark Perlman, 187-202. Ann Arbor: University of Michigan Press.

Jewekes, John, David Sawers, and Richard Stillerman (1969), *The Sources of Invention*. London: Macmillan.

Kasarda, John D. (1974), "The Structural Implications of Social System Size: A Three-Level Analysis." *American Sociological Review* 39 (1), 19-28.

Kimberly, John (1976), "Organizational Size and the Structuralist Perspective: A Review, Critique, and Proposal." *Administrative Science Quarterly* 21 (4), 571-97.

Lehmann, Donald, and Russell Winer (1997), *Product Management*. Chicago: Irwin.

Leonard-Barton, D. (1992), "Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development." *Strategic Management Journal* 13 (Summer Special Issue), 111-25.

Magaziner, Ira C., and Mark Patinkin (1989), *The Silent War.* New York: Vintage Books.

Magon, Kim M. (1988), "Seiko Corporation." In *International Directory of Company Histories*, ed. Thomas Derdak. Chicago: St. James Press.

Mansfield, Edwin (1988), "Industrial R&D in Japan and the United States: A Comparative Study." *American Economic Review* 78 (May), 223-8.

Mitchell, W. (1989), "Whether and When? Probability and Timing of Incumbents' Entry into Emerging Industrial Subfields." *Administrative Science Quarterly* 34 (2), 208-30.

_____ (1991), "Dual Clocks: Entry Order Influences on Industry Incumbent and Newcomer Market Share and Survival When Specialized Investments Retain their Value." *Strategic Management Journal* 12 (1), 85-100.

_____ , and K. Singh (1993) “Death of the Lethargic: Effects of Expansion into New Technical Subfields on Performance in a Firm’s Base Business.” *Organizational Science* 4 (May), 152-80.

Moorman, Christine (1995), “Organizational Market Information Processes: Cultural Antecedents and New Product Performance.” *Journal of Marketing Research* 32 (August), 318-35.

_____ , and Anne Miner (1997), “The Impact of Organizational Memory on New Product Performance and Creativity.” *Journal of Marketing Research* 34 (February), 91-106.

Moorthy, Sridhar K. (1984), “Market Segmentation, Self-Selection, and Product Line Design.” *Marketing Science* 3 (4) (Fall), 288-307.

Mount, Ellis (1994), *Milestones in Science and Technology.* Phoenix, AZ: Oryx Press.

Mowery, David C. (1983), “Industrial Research and Firm Size, Survival, and Growth in American Manufacturing, 1921-1946: An Assessment.” *Journal of Economic History* 63 (December), 953-80.

Nault, Barrie, and Mark Vandenbosch (1996), “Eating Your Own Lunch: Protection Through Preemption.” *Organization Science* 7 (May-June), 342-58.

Nelson, Richard R., and Sidney G. Winter (1982), *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press.

Olson, Eric M., Orville C. Walker, and Robert W. Ruekert (1995), “Organizing for Effective New Product Development: The Moderating Role of Product Innovativeness.” *Journal of Marketing* 59 (January), 48-62.

Patel, Pari, and Keith Pavitt (1995), “Patterns of Technological Activity: Their Measurement and Interpretation.” In *Handbook of the Economics of Innovation and Technological Change*, ed. Paul Stoneman. Cambridge, MA: Blackwell.

Pavitt, K., M. Robson, and J. Townsend (1987), “The Size Distribution of Innovating Firms in the UK: 1945-1983.” *Journal of Industrial Economics* 35 (March), 297-316.

Price, James L., and Charles W. Mueller (1986), *Handbook of Organizational Measurement*. Marshfield, MA: Pitman Publishing Inc.

Reich, Leonard S. (1985), *The Making of American Industrial Research: Science and Business at GE and Bell, 1876-1926.* New York: Cambridge University Press.

Reinganum, Jennifer F. (1983), “Uncertain Innovation and the Persistence of Monopoly.” The American Economic Review 73 (September), 739-48.

Rosenbloom, Richard, and Clayton Christensen (1994), “Technological Discontinuities, Organizational Capabilities, and Strategic Commitments.” *Industrial and Corporate Change* 3 (3), 655-85

Sahal, Devendra (1985), "Technological Guideposts and Innovation Avenues." *Research Policy* 14 (2), 61-82.

Sakudo, Jun, and Takao Shiba (1994), *World War II and the Transformation of Business Systems*. Tokyo: University of Tokyo Press.

Savitt, Ronald (1980), "Historical Research in Marketing." *Journal of Marketing* 44 (Fall), 52-8.

Saxenian, AnnaLee (1994), *Regional Advantage: Culture and Competition in Silicon Valley and Route 128.* Cambridge, MA: Harvard University Press.

Scherer, F. M. (1980), *Industrial Market Structure and Economic Performance*. Chicago: Rand McNally.

_____ (1991), "Changing Perspectives on the Firm Size Problem." In *Innovation and Technological Change*, eds: Zoltan Acs and David Audretsch, 24-38. New York: Harvester Wheatsheaf.

Schmookler, J. (1957), "Inventors Past and Present." *Review of Economics and Statistics* 39 (August), 321-33.

Schumpeter, Joseph (1942), Capitalism, Socialism, and Democracy. New York: Harper.

Smith, Douglas K., and Robert C. Alexander (1988), *Fumbling the Future: How Xerox Invented and then Ignored, the First Personal Computer.* New York: Morrow.

Smith, Ruth Ann, and David S. Lux (1993), "Historical Method in Consumer Research: Developing Causal Explanations of Change." *Journal of Consumer Research* 19 (March), 595-610.

Song, X. Michael, and Mark E. Parry (1997), "The Determinants of Japanese New Product Successes." *Journal of Marketing Research* 34 (February), 64-76.

Srivastava, Rajendra, Tasadduq Shervani, and Liam Fahey (1998), "Market-Based Assets and Shareholder Value: A Framework for Analysis." *Journal of Marketing* 62 (January), 2-18.

Staw, Barry M. (1981), "The Escalation of Commitment to a Course of Action." *Academy of Management Review* 6 (October), 577-87.

Sultan, Fareena, John U. Farley, and Donald R. Lehmann (1990), "A Meta-Analysis of Applications of Diffusion Models." *Journal of Marketing Research* 27 (February), 70-7.

Teitelman, Robert (1994), *Profits of Science: The American Marriage of Business and Technology*. New York: Basic Books.

Terrien, Fred W., and Donald L. Mills (1955), "The Effect of Changing Size Upon the Internal Structure of Organizations." *American Sociological Review* 20 (1), 11-3.

Tirole, Jean (1988), *The Theory of Industrial Organization.* Cambridge, MA: MIT Press.

Tornatzky, Louis G., and Mitchell Fleischer (1990), *The Process of Technological Innovation.* Lexington, MA: Lexington Books.

Tushman, M. L., and P. Anderson (1986), "Technological Discontinuities and Organizational Environments." *Administrative Science Quarterly* 31 (3), 439-65

_____ , and Charles A. O'Reilly (1997), *Winning Through Innovation: A Practical Guide to Leading Organizational Change and Renewal.* Boston: Harvard Business School Press.

Urabe, K., John Child, and T. Kagono (1988), *Innovation and Management: International Comparisons.* New York: Walter de Gruyter.

Urban, Glen, and John Hauser (1993), *Design and Marketing of New Products.* Englewood Cliffs, NJ: Prentice Hall.

Utterback, James M. (1994), *Mastering the Dynamics of Innovation.* Boston: Harvard Business School Press.

_____ , and W. J. Abernathy (1975), "A Dynamic Model of Process and Product Innovation." *Omega* 3 (6), 639-56.

Vernon, Raymond, Louis Wells, Jr., and Subramanian Rangan (1996), *The Manager in the International Economy.* Upper Saddle River, NJ: Prentice Hall.

Washington Post (1997), "And Then There Were . . . 3." (July 14), F5.

Wheelwright, Steven, and Kim B. Clark (1990), *Product Development Performance.* New York: The Free Press.

Williamson, Harold F. (1975), Evolution of International Management Structures. Newark: University of Delaware Press.

Wise, George (1985), *Willis R. Whitney, General Electric, and the Origins of U.S. Industrial Research.* New York: Columbia University Press.