The Market Evolution and Sales Takeoff of Product Innovations

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In contrast to the prevailing supply-side explanation that price decreases are the key driver of a sales takeoff, we argue that outward shifting supply *and* demand curves lead to market takeoff. Our fundamental idea is that sales in new markets are initially low because the first commercialized forms of new innovations are primitive. Then, as new firms enter, actual and perceived product quality improves (and prices possibly drop), which leads to a takeoff in sales. To provide empirical evidence for this explanation, we explore the relationship between takeoff times, price decreases, and firm entry for a sample of consumer and industrial product innovations commercialized in the United States over the past 150 years. Based on a proportional hazards analysis of takeoff times, we find that new firm entry dominates other factors in explaining observed sales takeoff times. We interpret these results as supporting the idea that demand shifts during the early evolution of a new market due to nonprice factors is the key driver of a sales takeoff.
(*New Product Development; Firm Entry; Entrepreneurship*)

1. Introduction

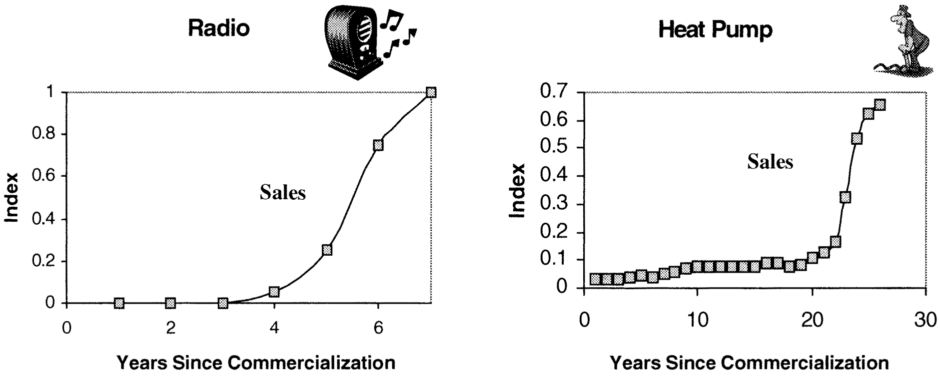
The early market evolution of successful consumer and industrial product innovations is generally characterized by an initial period of slow growth immediately after commercialization that is eventually followed by a sharp increase (e.g., Mahajan et al. 1990, Rogers 1995, Golder and Tellis 1997, Klepper 1997). For most new products, the "takeoff" point is clear because it corresponds to the first large increase in sales. The "hockey-stick" pattern of sales growth also seems to be popular among industry pundits as it is commonly used to depict the sales of really new technological products (e.g., Moore 1991). See the examples in Figure 1.

The time to sales takeoff can vary considerably across product innovations; some quickly achieve sales takeoff after commercialization, whereas others languish for years with low sales (e.g., Mahajan et al. 1990, Golder and Tellis 1997). Understanding the timing and causes of sales takeoff is critically important for industry analysts and managers because they have serious short- and long-term resource implications for research and development, product development, marketing, and manufacturing.

Conventional wisdom holds that sales takeoff times can primarily be explained in terms of supply-side factors (e.g., Bass 1980, Russell 1980, Metcalfe 1981, Foster 1986, Stoneman and Ireland 1983, Golder and Tellis 1997). According to this line of thought, increases in capacity associated with firm entry into a new market cause outward shifts in supply. This puts downward pressure on prices, which subsequently leads to increases in sales. Thus, the prevailing belief is that price is the key explanatory variable in determining the sales takeoff time; i.e., sales for product innovations are initially low due to their relatively

MANAGEMENT SCIENCE © 2002 INFORMS
Vol. 48, No. 8, August 2002 pp. 1024–1041
0025-1909/02/4808/1024$5.00
1526-5501 electronic ISSN

Figure 1 **The Sales Takeoff of Product Innovations**



high prices. Then, as prices of these products decline, the new product crosses a threshold of affordability and sales dramatically take off.

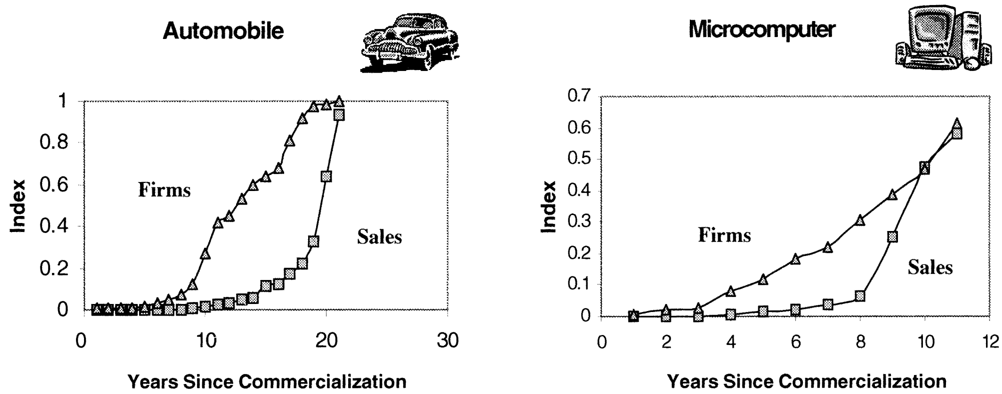
In this paper, we argue that this explanation is incomplete. Our fundamental idea is that a sales takeoff is caused by outward-shifting supply *and* demand curves.[1] Thus, we propose that sales are initially low due to the relative primitiveness of the first commercialized forms of new innovations, and increases in sales occur as new firms enter the market. Firm entry not only affects supply but also demand for the product because product improvements, expanded distribution, and increased consumer awareness of brand quality through promotional activities are key ways in which entering firms seek to differentiate themselves. We note that this explanation is consistent with findings in the economics and technology literature that firm competition in the early stages of new market growth focuses on continual product improvement (e.g., Shapiro 1986, Thomson 1986, Utterback 1994, Klepper 1997, Adner and Levinthal 2001).

To provide empirical evidence for this explanation, we examine the role of price decreases and new firm entry in the initial takeoff for a set of consumer and industrial product innovations commercialized in the United States during the last 150 years. While recognizing that firm entry creates additional supply-side capacity, we follow prior research suggesting that entry in the formative stages of a new market is primarily associated with demand-side changes from incremental product improvements and efforts by firms to develop market infrastructure. If entry is only associated with outward shifts in the supply curve, firm entry and price declines should be highly correlated, with each explaining roughly the same amount of variance in sales takeoff times. Based on a proportional hazards analysis, we find that price reductions and new firm entry are significant explanatory variables. However, price reductions account for less than 5% of the variance in sales takeoff times while new firm entry explains almost 50% of this same variance. We find that price reductions matter more for products that can be improved with low R&D costs. We interpret these results as supporting the idea that demand-side shifts during the early market evolution of new innovations due to nonprice factors is the key driver of the timing of a sales takeoff.

The remainder of this paper is organized as follows. In the next section, we present a theoretical framework for the role of firm entry in shifting demand and supply curves, and its impact on the timing of a sales takeoff. Section 3 presents an empirical analysis of the early market evolution and the takeoff phenomenon for a set of product innovations. Beginning with a description of the data sources and sample of consumer and industrial product innovations, we then outline our approach for identifying the takeoff times and present descriptive statistics on key time intervals and empirical results based on proportional hazards analyses of takeoff times. Finally, in §4 we discuss the implications associated with our empirical findings, and in §5 we outline several directions for future research.

[1] See, for example, the reviews in Stoneman (1983), Thirtle and Ruttan (1987), and Karshenas and Stoneman (1995).

Figure 2 The Evolution of Market Structure for Product Innovations



2. Explaining the Timing of a Sales Takeoff

Although our theoretical framework for the role of price decreases and incremental product improvements in leading to a sales takeoff can be formalized mathematically, for ease of exposition we present our ideas in terms of simple supply and demand concepts. See Agarwal and Bayus (2002) for a more detailed theoretical framework. Following the industrial organization literature (e.g., see the reviews in Geroski 1991, 1995), we focus on the role of firm entry in shifting the industry supply and demand curves. As suggested by Figure 2, we note that the literature finds a sharp takeoff in the number of firms in the early stages of market evolution (e.g., Gort and Klepper 1982; Rosegger and Baird 1987; Klepper and Graddy 1990; Utterback and Suarez 1993; Jovanovic and MacDonald 1994; Utterback 1994; Agarwal and Gort 1996; Klepper and Simons 1997, 2000). However, this research does not directly consider the sales takeoff phenomenon, as the emphasis is more on explaining the eventual evolution in market structure that occurs as an industry matures (Klepper 1997).[2]

As suggested by these studies, firm entry into a new market results in increased capacity. Particularly in the context of new product markets, firm entry also may involve an increase in competition or decreases in production costs due to new process innovations. Concentrating on this supply-side perspective, several researchers argue that a price decrease is the key factor leading to a takeoff in sales (e.g., Russell 1980, Foster 1986, Golder and Tellis 1997), and theoretical research concludes that optimal prices are decreasing when the supply curve shifts outward (e.g., Bass 1980, Metcalfe 1981, Stoneman and Ireland 1983, Klepper 1996). Empirical studies supporting this conclusion include Golder and Tellis (1997), who find quick sales takeoff times for new consumer durables that have low relative prices, and Agarwal (1998) who reports declining price trends for most new consumer and industrial products.

At the same time however, the literature also indicates that firm entry during the early years of market evolution can shift the demand curve outward. Demand increases stem from firm activities in new markets that are geared towards increasing actual or perceived product quality.[3] As suggested by Gort and Klepper (1982), early entrants often bring crucial

[2] Kim et al. (1999) propose a multi-equation diffusion model for sales and the number of competitors. However, their ad hoc model formulation assumes that an imitation effect within the consumer and firm populations is the only driving force behind market growth, and their empirical analysis of three products does not concentrate on the early stages of market evolution and sales takeoff.

[3] Using methods like hedonic price analysis to account for changes in product quality over time has a long and rich history in the economics literature (e.g., see the review in Gordon 1990). However, we do not employ such methods in our study. Aside from the fact that suitable data to conduct these analyses are unavailable for the product innovations we study, it is not clear that these methods are appropriate for the early market time periods of interest to our research. In particular, hedonic analyses can only evaluate quality improvements when the product form has stabilized (i.e., the set of important attributes is established), which is not the case during the

new information, skills, and product quality improvements that result in demand increases. This is particularly important because the early commercialized forms of new innovations are generally quite primitive (e.g., Rosenberg 1982, 1994; Shapiro 1986; Thomson 1986; Klepper 1997). Further, as a new market evolves, the consumer base expands due to increases in product offerings as well as product differentiation attempts by both new entrants and incumbents that respond to the threat caused by new entrants (e.g., Brown 1981, Bayus and Putsis 1999). Several researchers note that competition during the early stages of market growth is primarily on the basis of continued product improvements (e.g., see reviews in Geroski 1991, 1995 and Klepper 1997). Consistent with this idea, Gort and Konakayama (1982) report a positive and significant relationship between firm entry and the rate of patenting for a sample of seven industrial innovations.[4]

In addition to the above studies examining broad indicators of product quality improvements through entry across several product markets, detailed evidence of the relationship between early firm entry and product improvements is also available from various industry case studies (e.g., Christensen 1993, Utterback 1994). Consider, for example, the evolution of major product and process innovations (innovations ranked four or higher on a seven-point scale by Abernathy et al. 1983) in the automobile industry shown in Table 1. We note that firm entry in this industry accelerated only after 1899, and sales of automobiles did not take off until 1909. As discussed in Klepper and Simons (1997), product innovation in the automobile industry was greatest from commercialization until the first decade of the twentieth century, whereas process innovation was very low during this period. More importantly, Klepper and Simons (1997) note that it was new entrants that contributed the largest share of product innovations, including the front-mounted four-cylinder engine, shaft-driven transmission, and pressed steel frame, and caused the automobile to evolve from its bicycle and carriage origins towards the design of "luxury" cars pioneered in France. Introduced in 1908, Ford's Model T represented the culmination of many of these incremental product improvements. Not surprisingly, sales dramatically increased in 1909. The later history of the automobile industry shows that the majority of process improvements came after 1909, with the most dramatic improvements in manufacturing occurring after the sales takeoff, when Ford pioneered the moving assembly line (1913–1914). Klepper and Simons (1997) state that with few exceptions, the industry's major process innovations were dominated by the largest firms (Ford and General Motors). Although anecdotal in nature, this example strongly suggests that product improvements in the automobile industry occurred during the early years of market evolution when firm entry was high.

Studies also indicate that product improvements, relative to process improvements, are typically emphasized in the early stages of a new market (e.g., Abernathy and Utterback 1978; Utterback 1994; Klepper 1996, 1997; Klepper and Simons 1997). Thus, it is not surprising that the dramatic price decreases due to declining costs from process improvements and increasing cumulative sales volume are usually observed only after the sales takeoff (e.g., Bass 1980, Metcalfe 1981, Stoneman and Ireland 1983).

In addition to incremental product innovations, demand for the product may also increase from efforts by incumbents and new firms to increase perceived product quality.[5] For example, extensive advertising and promotion may be required to educate and inform potential consumers about the benefits of a

early evolution of new markets. See Gordon (1990) for a discussion of other pitfalls associated with hedonic analyses.

[4] While patent statistics may seem like an obvious measure of incremental product improvements, they have several limitations. For example, innovations vary in their impact on the technological environment and a count of patents will not necessarily capture the differences in the importance of innovations (e.g., Schmookler 1966, Pakes 1985). Gort and Klepper (1982) note that patent counts do not clearly distinguish between product and process improvements, or between major and minor innovations. Industries can also differ in their propensity to patent, due in part to existing trade-offs between the exclusive rights granted by a patent and the loss of secrecy. See Griliches (1990) for a general review of patent statistics and their use.

[5] We thank an anonymous reviewer for bringing our attention to factors associated with new firm entry that may improve perceived quality of the product innovation.

Table 1 The Evolution of Major Product and Process Innovations in the Automobile Industry

Year	Firm	Product Innovation	Process Innovation
1890 Commercialization			
1893	Duryea	Single plate clutch	
1895	Haynes-Apperson	Aluminum engine	
1896	King	En-bloc engine	
1896	Duryea		1st multiple production of one car design
1898	Duryea	Internal-expanding brakes	
1898	Columbus	Enclosed car body of wood/steel	
1899 Number of Firms Takes Off			
1899	Packard	Automatic spark advance	
1900	Most Producers		Gasoline engine mounted in front
1901	Autocar	1st shaft-driven Am. car	
1901	Oldsmobile		1st mass-produced auto
1902	Locomobile	4-cylinder, front-mounted engine	
1902	Northern	3-point suspension of power unit	
1902	Northern	Planetary gear set	
1902	Northern	Integral engine and transmission unit	
1902	Marmon		1st all metal body (aluminum casting)
1903	A.O. Smith	Pressed steel frame	
1904	Ford	Torque tube drive	
1906	Ford	Wiring harness for elec. system	
1907	Ford		Multiple simultaneous machining ops
1908	Ford	Detachable cylinder heads	
1908	Ford	Magneto integrated into flywheel	
1908	Ford		Vanadium steel components
1909 Sales Takeoff			
1910	Ford		1st branch assembly plants
1913	Ford		Moving flywheel-magneto assembly line
1914	Ford		Elevated moving chassis assembly line
1914	Cadillac (GM)	1st large scale production of V8 engine	
1917	Ford		Baked enamel finishes
1920	Ford		Continuous pouring of molten iron

Source: Abernathy, Clark, and Kantrow 1983.

new product innovation (e.g., the first phonographs brought the famous opera singer Caruso into your home). As suggested by Brown (1981), the timing of a sales takeoff for a product innovation may also be related to the existence and evolution of a market infrastructure; i.e., new firm entry may proxy for infrastructure development. This infrastructure can take different forms and might be established in various ways. New distribution channels and pricing arrangements may be necessary for some innovations (e.g., sewing machines required the establishment of new retail outlets as well as credit terms). Widespread adoption of product innovations often requires the development of complementary products and services (e.g., automobiles needed roads and gas stations). These fundamental infrastructure developments often take place as a result of new entry into the market, either as new information is brought in by entrants or as competitive strategies of incumbents to stave off entry.

Thus, based on the discussion so far, new firm entry clearly impacts both the supply and demand of a new product innovation. Accordingly, our first hypothesis highlights the importance of new firm entry in the takeoff of product innovations.

Hypothesis H_1. *Product innovations with a high (low) level of new firm entry have short (long) takeoff times.*

We next address the relative importance of demand- and supply-side effects associated with firm entry as explanatory factors for sales takeoff. The related literature has generally emphasized supply-side effects, and thus concludes that price declines are the crucial determinant of sales takeoff (e.g., Golder and Tellis 1997). However, outward-shifting demand and supply results in unambiguously increasing sales but an indeterminate price effect. Further, the demand-increasing efforts of firms may come at additional costs, which can affect product supply. For example, crucial R&D expenditures in the early years of market evolution may actually increase costs, thereby offsetting effects of outward shifts in supply on price. Thus, the possibility of outward-shifting demand and supply implies that sales increases may be associated with *either* higher *or* lower prices. Importantly, this ambiguity in price effects can possibly account for actual industry cases such as turbojet engines, cathode ray tubes, and microwave ovens, in which sales took off even though prices were increasing.

By studying the relationship between price decreases, new firm entry, and takeoff times across a set of product innovations, we can explore the role of shifting supply and demand curves in leading to a sales takeoff. To the extent that supply-side factors alone drive takeoff times, new firm entry will be associated with greater supply, which in turn will lead to lower prices and a sales takeoff. In this case, the effects of new firm entry on takeoff will operate through price (i.e., new firm entry → price → takeoff). In addition, price declines and firm entry will be highly correlated (since firm entry leads to price declines *only*), which suggests that each variable will separately account for very similar amounts of variance in observed takeoff times. Thus, we have:

Hypothesis H_{2A}. *Supply-side effects alone explain the takeoff times of product innovations.*

Based on our discussion in this section, we offer a competing hypothesis. New firm entry may be associated with changes in supply *and* demand. In this case, firm entry will contribute some explanatory power above and beyond price decreases in explaining observed takeoff times (i.e., in addition to price → takeoff, we also have new firm entry → takeoff). Moreover, if demand shifts due to the non-price factors associated with new firm entry is a key driver of takeoff times, then firm entry will dominate price as an explanatory variable of takeoff times (i.e., new firm entry → takeoff will explain more variance in takeoff times than price → takeoff). Thus, we also have:

Hypothesis H_{2B}. *Demand-side effects dominate supply-side effects in explaining the takeoff times of product innovations.*

3. An Empirical Analysis of Market Takeoff

In this section, we focus our attention on the sales takeoff time and possible explanations for its variation across products. Similar to prior research efforts, we do not consider the possible sales patterns after takeoff (e.g., some products like 8-track tape and videodisc players did achieve a sales takeoff but had very short market lifetimes). Because we use secondary data to empirically study the market evolution of product innovations, our study is consistent with prior research in that we only consider "successful" innovations. However, this concern is mitigated by the fact that new products historically exhibit a wide variation in the time to sales takeoff. Since several products in our sample take well over 20 years before achieving a takeoff (e.g., see Figure 1), innovations that could have been considered "failures" based on their very low sales in the early years of industry formation are included in our analysis. We also examine the takeoff phenomenon for industrial as well as consumer products.

3.1. Data Sources

To develop an appropriate sample of innovations, we began by consulting various technical sources, scientific journals, chronologies, and encyclopedias of new inventions. To be considered for inclusion in our study, a consumer or industrial product innovation had to be deemed significant by experts in the field and result in entirely new product markets rather than improvements or subsections of existing

Table 2 Key Dates for Our Sample of Product Innovations

Product	"Invention" year	"Commercialization" year	Firm takeoff year	Sales takeoff year
Sewing machine	1830	1849	1853	1859
Automobile	1771	1890	1899	1909
Phonograph record	1877	1897	1917	1919
Vacuum cleaner	1907	1911	1928	1934
Outboard engine	1905	1913	1916	1936
Electric blanket	1914	1915	1923	1952
Dishwasher	1898	1915	1951	1955
Radio	1912	1919	1922	1923
Clothes washer	1901	1921	1923	1933
Freon compressor	1930	1935	1938	1964
Cathode ray tube	1897	1935	1943	1949
Clothes dryer	1930	1935	1946	1950
Electric razor	1928	1937	1938	1943
Styrene	1831	1938	1943	1946
Piezoelectric crystals	1880	1941	1944	1973
Home freezer	1924	1946	1947	1950
Antibiotics	1928	1948	1950	1956
Turbojet engine	1934	1948	1949	1951
Ballpoint pen	1888	1948	1957	1958
Garbage disposer	1929	1949	1953	1955
Magnetic recording tape	1928	1952	1953	1968
Heat pump	1851	1954	1960	1976
Computer printer	1944	1960	1971	1979
Home microwave oven	1947	1970	1974	1976
Monitor	1927	1971	1975	1981
Microcomputer	1962	1974	1977	1982
Home VCR	1951	1974	1975	1980
Compact disc player	1979	1983	1984	1985
Cellular telephone	1970	1983	1985	1986
Optical disc drive	1979	1984	1987	1993

markets. Once an appropriate list of innovations was identified, the hurdle then became the availability of consistent data for variables related to both demand (sales, price) and market structure (number of firms).

Accurate historical data on new product markets are typically very difficult to obtain, and even harder is the task of matching sales and price information to data on entry and the number of firms competing in the market. While there are several consumer and industrial product innovations for which sales and price information are available, often data on the entry, exit, and number of firms are not readily available (or vice versa). After several hundred person-hours of research, we were able to develop consistent time-series data on the key variables for 30 product innovations introduced in the United States between 1849 and 1983 (see Table 2 for a list of the product innovations). Our sample size compares favorably with the average sample size of 14 product categories used in prior new product diffusion studies (Sultan et al. 1990). These 30 innovations encompass a broad spectrum of important products introduced over the past 150 years, and include a diverse mix of consumer and industrial products, as well as products that vary in their capital and technological intensiveness. In addition, the product innovations we study overlap with those studied by other researchers (i.e., Table 2 includes 13 of the new consumer durables examined by Golder and Tellis 1997 and 11 of the consumer and industrial innovations studied by Gort and Klepper 1982).

Annual data were gathered for these 30 products from a variety of published sources (see the Appendix for a summary of these sources). Because we had no prior information on the actual takeoff times for each product, the collected data generally extended well beyond the introduction and growth stages. Information on the commercialization date, entry, exit, and number of firms producing the product in any given year were mainly compiled from the *Thomas Register of American Manufacturers*, a source that has been widely used to study the evolution of markets (e.g., Gort and Klepper 1982, Klepper and Graddy 1990, Jovanovic and MacDonald 1994, Agarwal and Gort 1996, Klepper and Simons 2000, Robinson and Min 2001).[6] The *Thomas Register*, which dates back to 1906, is a national buying guide that is used primarily by purchasing agents.[7] In extensively describing various sources of business information, Lavin (1992) states that the *Thomas Register* is the best example of a directory that provides information on manufacturers by focusing on products. According to Lavin (1992, p. 129), "The *Thomas Register* is a comprehensive, detailed guide to the full range of products manufactured in the United States. Covering only manufacturing companies, it strives for a complete representation within that scope." In choosing product markets, we excluded those product markets for which there was a lack of consistency of boundaries between the *Thomas Register* and those defined by other agencies such as the U.S. Census of Manufacturers and various trade organizations. This ensured accurate matching of the data for the number of firms with data on sales and price information. In addition, multiple *Thomas Register* categories were combined as needed to ensure the inclusion of all competitors in a market.[8] Firm listings were also subjected to several checks to ensure actual market entry rather than a renaming, relocation, or merger between existing firms (see Agarwal 1997 for details). We also used the asset size class reported in the *Thomas Register* to categorize firms as large or small after appropriately adjusting the boundaries of these classes over time to account for inflation.[9]

Data for sales and average price were compiled from a variety of sources (see Appendix A) widely used by other researchers (e.g., Golder and Tellis 1997, Agarwal 1998). The annual prices for each product were either deflated by the Consumer Price Index (consumer products) or the Producer Price Index (industrial products) to correct for inflation and general productivity changes (economywide rather than product specific). Finally, we also estimated an "invention" year for each product innovation based on several published sources (e.g., Giscard d'Estaing 1986) and analyses (e.g., Jewkes et al. 1958, Enos 1962, Mensch 1979, Kohli et al. 1999). We recognize, however, that there is considerable controversy over the accuracy of dating inventions (e.g., Freeman et al. 1982, Rosenberg 1994). Thus, these dates are only included to fill out the timeline of market evolution, and should be used with caution.

3.2. Key Variable Definitions and Hypotheses

Our two key explanatory variables are price declines and firm entry. In addition, we consider several control variables, including year of commercialization, World War II, and product type. We do not include other economywide variables such as GNP because none were significant in explaining the takeoff times.

[6] Some product innovations introduced in the nineteenth century were added because reliable information was available from reputable published sources (see Appendix A). While we recognize that many innovations were commercialized in local markets shortly after their invention (often by the inventors themselves), we follow Gort and Klepper (1982) and Agarwal and Gort (1996) by assuming that the "commercialization" year is the first year the product was listed in the *Thomas Register*.

[7] The importance of imports in manufacturing has increased over the last few decades. The *Thomas Register* includes foreign manufacturers of the product if the firm maintains an office or distribution channel for its product in the United States. Foreign firms that operate plants in the United States are also included.

[8] For example, "Machinery: Dishwashing and Dishwashers" are two categories that list manufacturers of dishwashers. In these instances when firms might be listed in each category, we were careful to avoid the double counting of firms.

[9] The smallest of the five broad asset categories reported in the *Thomas Register* represented assets less than $1.4 M (in 1982 dollars) at the turn of the century. We used this cut point to define "small" firms and, over time, consecutive asset categories were added to the "small" firm definition to appropriately adjust for inflation.

Table 3 Variables and Descriptive Statistics (Between Commercialization and Sales Takeoff)

Variable	Definition	Mean	Standard deviation
Changes in price (*Price*)	Estimated coefficient from an exponential time trend	−0.06	0.14
New firm entry	$\frac{1}{n-1}\sum_{i=1}^{n-1}\frac{\#\ entrants_i}{\#\ firms_i}$	0.30	0.20
Year of commercialization	Year of product commercialization (see Table 2)	1939.83	30.11
World War II	= 1 if WWII occurred between commercialization and takeoff = 0 otherwise	0.23	0.42
Product type (*R&D costs*)	Average R&D expenditures as a percentage of sales (1987–1997)	4.92	3.33

The variables we consider are summarized in Table 3 as well as briefly discussed below.

Changes in Price. To measure changes in price, we follow prior observations (e.g., Bass 1995) and empirical analyses (e.g., Bayus 1992) by fitting an exponential time trend ($\lambda e^{\theta t}$) to the annual price series for each innovation. As expected, excellent fits are obtained. In this way, our measure of changes in *Price* is the estimated exponential coefficient θ (which is independent of takeoff times).

New Firm Entry. We define the annual percentage of new entrants as the ratio of the number of entrants (net of exits) to the total number of competitors in any year and compute our measure of *New Firm Entry* between commercialization and the year prior to sales takeoff as the average of the annual values during that period. Letting n = period in which sales take off, we have

$$New\ Firm\ Entry = \frac{1}{n-1}\sum_{i=1}^{n-1}\frac{\#\ entrants_i}{\#\ firms_i}.$$

New Firm Entry for the other time periods is defined similarly.

Year of Commercialization. Because our sample of product innovations encompasses a time horizon of more than a century, it is highly likely that there have been significant changes in the economic climate in which firms operate. Some notable examples include the broad leaps in communications and transportation, the general growth in GNP, and the expansion of populations and markets (through globalization, etc.). The year of product commercialization is one way to control for any systematic changes that may have occurred in the underlying structural conditions and barriers to entry across our sample of product innovations over time. Consistent with prior research, we expect that the effect of *Commercialization Year* on the probability of takeoff is positive.

World War II. Major economic upheavals due to events such as World War II can affect takeoff times. Therefore, our analyses include a dummy variable controlling for the possible effects of *World War II* on takeoff times. We expect that the takeoff time is greater for an innovation if World War II occurred between its commercialization and its time to firm or sales takeoff.[10]

Product Type. The variation in takeoff times across product innovations may be related to product characteristics.[11] In particular, the resources required to improve an early commercialized form of a new product is expected to be negatively associated with takeoff times. We control for the possible relationship between takeoff times and product improvement costs by including a measure of R&D costs. Cross-sectional differences in the product markets are measured by constructing a "steady-state" measure of *R&D Costs*, calculated as average R&D expenditures as a percentage of sales between 1987–1997 for each innovation in our sample (at the three-digit SIC level) using NSF data.[12] Although we recognize that

[10] Although not reported here, our analyses revealed that effects due to World War I and the Great Depression are insignificant.

[11] We also examined a dummy variable capturing whether the innovation is a component or factor of production for other product "systems" (i.e., outboard engine, freon compressor, cathode ray tube, styrene, piezoelectric crystals, turbojet engine, magnetic recording tape, heat pump) or a good for final consumption. No significant results were obtained.

[12] Data obtained from ⟨http://www.nsf.gov/sbe/srs/nsf99358/tables/nsf97a21.xls⟩. See also, National Science Foundation, Division of Science Resources Studies (1999) *"Research and Development in Industry: 1997,"* NSF 99-358.

this is a crude measure, it represents the best consistent data that are available.[13] We also note that the mean *R&D costs* in our sample of products (4.92) is not statistically different from the mean *R&D costs* across all United States industries (4.67), indicating that our sample does not overrepresent high R&D cost industries.

3.3. Determining Takeoff Times

To consistently identify takeoff times, we follow Gort and Klepper (1982) and Agarwal and Gort (1996) by using a statistical procedure that is based on a generalized version of discriminant analysis. Briefly, this methodology allows us to distinguish between any two consecutive intervals by examining the data on annual percentage change in sales (for the sales takeoff) and annual net entry rates (for firm takeoff) for each product. To determine the takeoff year for a product, we first partition the appropriate series into three categories—the first and third categories contain the years where the percentage change in sales or net entry rate clearly reflect the pre- and posttakeoff periods, respectively. Periods for the "in-between" years are then optimally classified based on mean values.

As a final validity check, we also carefully matched the calculated takeoff times with information in available published histories of the product innovations. Applying this procedure to each of our 30 product innovations gives the takeoff times reported in Table 2. For the set of product innovations we consider, it is clear that the firm and sales takeoff years do indeed represent sharp increases over the prior year since, on average, the percentage change in the number of firms at firm takeoff is +123% and the percentage change in sales at sales takeoff is +136%.

[13] We note that relying on the later years for this measure of R&D costs may seem biased against products introduced early in the century since technological intensity varies over the product life cycle and is expected to be highest when a product innovation is first introduced. However, this concern is partly alleviated by two facts. One, the technological intensity of the industries is remarkably stable over a long period of time (e.g., chemicals, aircrafts, communications, etc). Two, several of the product innovations in our study that are associated with high R&D costs were introduced early in the century (e.g., automobiles).

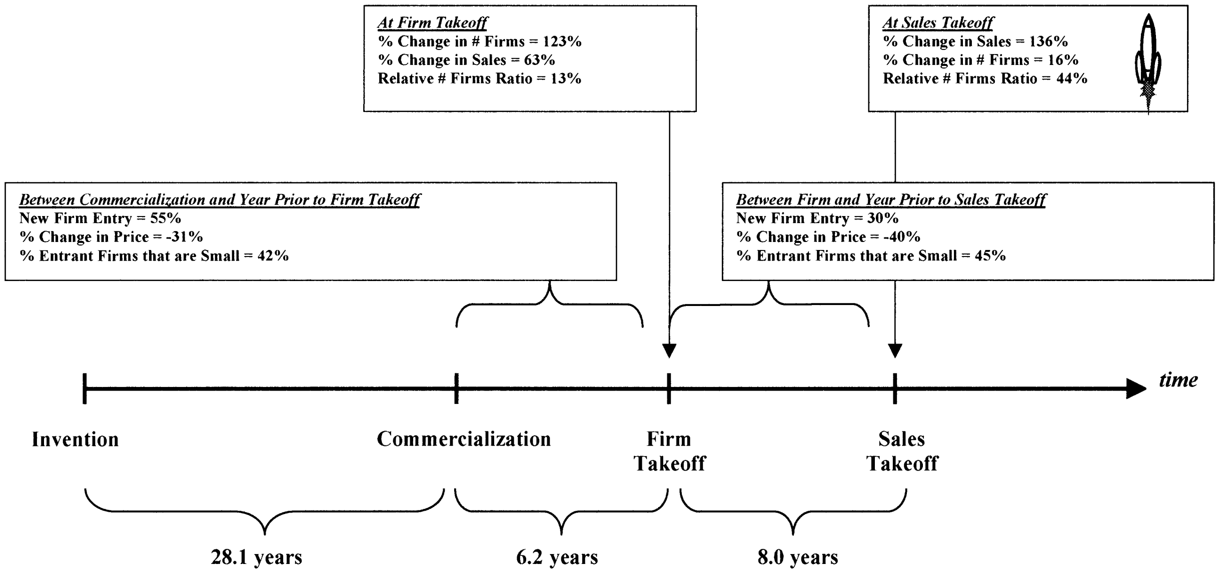
3.4. Descriptive Statistics

Figure 3 summarizes the descriptive statistics on key variables. In agreement with the literature (e.g., Jewkes et al. 1958, Mensch 1979, Kohli et al. 1999), the time between invention and commercialization is generally very long (the average for our product innovations is almost 30 years). Consistent with Schumpeter's (1939, 1943) thesis that early entrants into a new market base their entry decisions on expected rather than realized sales, Table 2 shows that firm takeoff precedes sales takeoff for every one of our 30 product innovations. Moreover, for 26 of the 30 innovations, firm takeoff preceded sales takeoff by three or more years. As shown in Figure 3, the mean time between commercialization and firm takeoff is just over six years for our set of innovations, and the mean time between firm and sales takeoff is eight years.

Table 4 suggests that the time intervals vary by commercialization year. In particular, the time between commercialization and firm takeoff has significantly declined over time for this set of product innovations, and the time between commercialization and sales takeoff has also shrunk. Interestingly, the time between firm and sales takeoff has not significantly declined over this period. In addition, Table 4 suggests that the fraction of large entrants has increased over the last 150 years (e.g., see also Chandler 1977).

Figure 3 reports that *New Firm Entry* between commercialization and firm takeoff for our set of innovations is 55%; i.e., over half of the competitors in each year before the firm takeoff tend to be new entrants. However, these firms still only represent 13% of all potential competitors (see the Relative # Firms Ratio in Figure 3, defined as the ratio of the number of firms to the peak number of firms over the observed product life cycle). *New Firm Entry* between the firm and sales takeoff is 30%, and by the year of sales takeoff, 44% of all the potential competitors have already entered the market. Together, these results indicate that almost one-third of all the eventual competitors (i.e., Relative # Firms Ratio at sales takeoff less Relative # Firms Ratios at firm takeoff) enter in the period between firm and sales takeoff; i.e., a large fraction of the competitors in a new market enter before the

Figure 3 Descriptive Statistics for the Market Evolution of Product Innovations (Means)



sales takeoff (although over half of a new market's eventual competitors do enter after the sales takeoff).

Based on the estimated exponential price trends for each innovation, Figure 3 also reports that the percentage change in price between commercialization and year prior to firm takeoff is −31%, and between firm and year prior to sales takeoff is −40%. Clearly, prices are declining over time for this set of product innovations.

Although the details are not reported here, we also explored the potential relationship between firm entry, entrant size, and market opportunity. We find that *New Firm Entry* between commercialization and year prior to firm takeoff is a significant negative correlate with the percentage of entrant firms that are small ($r = -0.41$; $p \leq 0.05$). On the other hand, entrant size is not significantly related to *New Firm Entry* between firm and year prior to sales takeoff. Although entrepreneurs may play a pivotal role in the initial commercialization of a product innovation (e.g., Schumpeter 1943, Feller 1967), these results suggest that the entry of larger firms with greater resources and commitment to build the market may attract other firms to the nascent industry. These results are also consistent with the idea that potential industry participants need some signal (e.g., the participation

Table 4 The Market Evolution of Product Innovations

Products commercialized	Invention to commercialization	Commercialization to firm takeoff	Firm to sales takeoff	Commercialization to sales takeoff
Average number of years				
Before WWII	27.07	9.29	9.43	18.71
After WWII	29.00	3.50	6.75	10.25
	(−0.16)	(2.18)[b]	(0.89)	(2.40)[a]
% Entrants that are small				
Before WWII	NA	56	52	54
After WWII	NA	30	40	36
		(2.71)[a]	(1.20)	(2.20)[b]

Notes. $n = 30$; [a]significant at 0.01 level; [b]significant at 0.05 level; t-statistics in parentheses.

of larger firms) that an infant industry is "legitimate" before they enter en masse (e.g., Aldrich 1999, Van de Ven et al. 1999). We also find that *New Firm Entry* between firm and year prior to sales takeoff is a significant negative correlate with the relative number of firms at takeoff ($r = -0.40$; $p \leq 0.05$). At the same time, the relative number of firms is not significantly related to *New Firm Entry* between commercialization and year prior to firm takeoff. These results suggest that the entrants after firm takeoff base their entry decision on perceived market opportunities as reflected by the remaining competitive potential associated with the product innovation. Not surprisingly, these entrants generally want to get to market before the competitive landscape is fully established (e.g., Lieberman and Montgomery 1998).

3.5. Estimation Approach and Results

Following the related literature, we use Cox's (1972) proportional hazards regression model to study sales takeoff times. The proportional hazards model is appropriate because it allows for estimation of the determinants of the hazard rate, i.e., the probability of takeoff in period t given that the product has not taken off until period $t-1$. See Helsen and Schmittlein (1993) for an excellent discussion of this model and its benefits over other modeling approaches.[14]

For the ith product, the hazard rate function $h_i(t)$ is defined as

$$\log h_i(t) = \log h(t; x_i) = \alpha(t) + x_i'\beta, \qquad (1)$$

where $\alpha(t)$ is an arbitrary and unspecified baseline hazard function, x_i is a vector of measured explanatory variables for the ith product, and β is the vector of unknown coefficients to be estimated. As suggested by Allison (1984), we do not include a term for unobserved heterogeneity because we only analyze nonrepeated events. Parameter estimation is accomplished using the partial likelihood method as implemented in the SAS PHREG procedure. To account for the possibility that two product innovations have the same observed takeoff time, we assume that there is a true but unknown ordering for the tied events times and use the EXACT method in the SAS PHREG procedure (e.g., see Allison 1995 for details).[15]

Table 5 reports the results of our proportional hazards analyses of sales takeoff times.[16] We note that the same basic results are also obtained for various subsamples of the product innovations. We use McFadden's (1974) Likelihood Ratio Index, ρ^2 (which, for our models, is the same as the U^2 measure discussed by Hauser 1978), as a measure of model fit ($0 \leq \rho^2 \leq 1$). The Likelihood Ratio Index is calculated as $1 - L(\mathbf{x})/L_0$, where $L(\mathbf{x})$ is the log likelihood of the model with covariates and L_0 is the null model.

From the results presented in Table 5, *New Firm Entry* is significant and in the expected direction for all models. Thus, H_1 is strongly supported; i.e., a sales takeoff occurs quickly (slowly) for innovations with a high (low) fraction of new entrants. As indicated by the results for Model 1, *Price* decreases are significantly related to sales takeoff times. In addition, Model 4 reports the estimation results with the other control variables: *Commercialization Year* and *World War II* are not significant, whereas *R&D Costs* is negative and significant. This latter result suggests that product innovations for which there are relatively high costs of improvement tend to have longer takeoff times.

[14] As suggested by a reviewer, alternative estimation approaches are possible. Not surprisingly, the conclusions from a GLS regression analysis of sales takeoff times are very similar to our reported Cox proportional hazards results (e.g., Kieffer 1988). Because we have no time-varying explanatory variables, a complementary log–log analysis of our detailed time-series data would offer no additional insights (e.g., Allison 1995). Given that our interest is in explaining the conditional probability of a takeoff, we employ a proportional hazards model (see also, Greene 2000).

[15] Because the price trend for some of our product innovations is positive, we allow for the possibility of nonproportional hazards using stratification (Allison 1995). In this case, $\alpha(t)$ in Equation (1) is replaced by $\alpha_j(t)$ to allow the arbitrary function of time to differ for the two situations (i.e., θ is positive or negative). This model is estimated using the partial likelihood method by: (1) constructing separate partial likelihood functions for the two groups of innovations, (2) multiplying these two functions together, and (3) choosing values of β that maximize this function. This procedure is implemented in the SAS PHREG procedure using the STRATA option (see Allison 1995 for details).

[16] The conclusions in this section are supported by other hazard analyses not reported here (but which are available from the authors) for the time between commercialization and firm takeoff and the time between firm and sales takeoff.

Table 5 Proportional Hazards Analysis of the Probability of Sales Takeoff After Commercialization

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Price	−6.54	–	1.98	4.50	−17.38
	(3.23)[a]		(4.24)	(4.22)	(13.31)[c]
New Firm Entry	–	16.17	16.64	22.16	21.09
		(3.69)[a]	(3.86)[a]	(6.01)[a]	(5.91)[a]
Commercialization Year	–	–	–	0.01	0.01
				(0.01)	(0.01)
World War II	–	–	–	0.37	0.28
				(0.86)	(0.87)
R&D Costs	–	–	–	−0.27	−0.08
				(0.14)[a]	(0.20)
Price × R&D Costs	–	–	–	–	3.37
					(1.96)[b]
ρ^2	0.04	0.46	0.46	0.51	0.55
−2LL	98.18	55.01	54.78	49.49	45.74
Chi-Square	3.68[b]	46.85[a]	47.08[a]	52.37[a]	56.12[a]

Notes. $n = 30$; [a]significant at 0.01 level; [b]significant at 0.05 level; [c]significant at 0.10 level; one-tail significant tests; standard errors in parentheses.

Following Cohen and Cohen (1983), we compare the ρ^2 values of the various models to determine the relative importance of the factors. Clearly, the ρ^2 values for the single-variable model of *New Firm Entry* (Model 2: $\rho^2 = 0.46$) is much larger than the single-variable ρ^2 model value for *Price* (Model 1: $\rho^2 = 0.04$). In addition, the ρ^2 values of the multivariate models (Models 3 and 4) are only marginally larger than the single-variable model of *New Firm Entry* (Model 2), indicating that the other variables do not contribute much additional explanatory power over *New Firm Entry*. Thus, it must be the case that our measure of *New Firm Entry* captures much more than just the effects of price decreases alone.[17]

We also test whether the effects of firm entry on takeoff operate through price; in other words, whether price mediates the relationship between firm entry and takeoff times (i.e., new firm entry → price → takeoff). Following Baron and Kenny (1986), price acts as a mediator when: (1) takeoff time is significantly related to price and firm entry separately, (2) price and firm entry are significantly related, and (3) a significant relationship between firm entry and sales takeoff time disappears when price is added to the model. Condition 1 is satisfied because the results for Model 1 in Table 5 are significant, but Condition 2 is not met because the Pearson correlation between *Price* and *New Firm Entry* is insignificant ($r = -0.18$; $p \leq 0.35$). Examining the results for Models 2 and 3, we also find that Condition 3 is not met; i.e., rather than having the relationship between *New Firm Entry* and takeoff time disappear with the addition of *Price*, *Price* is insignificant in a model with *New Firm Entry*.[18] Thus, we find no evidence that price mediates the relationship between firm entry and takeoff times (which is contrary to H_{2A}).

Taking these results together, we find strong evidence that firm entry into a new market dominates price in explaining the timing of a sales takeoff. Thus,

[17] It is noteworthy that the ρ^2 values we report in Table 5 (Models 2–5) are much higher than the ρ^2 value of 0.31 reported by Golder and Tellis (1997).

[18] We note that there may be several reasons why some factors are significant in a single-variable model, yet insignificant in a multivariate model. For example, it is possible that after controlling for *New Firm Entry*, the other factors do not affect the likelihood of takeoff. More likely though, is that the model without *New Firm Entry* is misspecified (i.e., there is an omitted variable in this model). Thus, it may be that the estimated coefficient for *Price* is biased upwards, resulting in the significant conclusions for the single-variable model in Model 1.

H_{2B} is supported. Given our discussion in §2, we interpret these results as supporting the idea that demand shifts due to actual and perceived improvements in product quality during the early market evolution of innovations is the key driver of a sales takeoff.

At the same time, however, the fact that prices are generally declining over time suggests that the supply curve is also shifting outward. Since both the demand and supply curves are shifting outward, we further explore two possible explanations for our empirical results that firm entry explains sales takeoff better than price reductions.[19] First, it may be that growth in demand leads to a transitory disequilibrium which delays price reductions. In this case, the duration of disequilibrium should be inversely related to entry barriers in the market. However, as noted above, the correlation between *Price* (a proxy for price reduction lags)[20] and *New Firm Entry* (a proxy for entry barriers) is insignificant. This suggests that the speed of price declines (and thus price lags) is not related to barriers to entry. A second possible explanation is that the R&D costs related to product improvements may vary greatly across innovations and that innovations with high R&D costs may have high prices that only slowly decline over time. Consistent with this idea, we find that the correlation of *Price* and *R&D Costs* is positive and significant ($r = 0.43; p = 0.01$). In this case, *Price* and *R&D Costs* should also have an interactive effect on the probability of takeoff. From Model 5 in Table 5, we find that *Price* and *New Firm Entry* are significant and have the expected coefficient signs.[21] Moreover, the interaction of *Price* and *R&D Costs* is significant and has a positive effect on the probability of a sales takeoff for our set of product innovations. Because the coefficient sign of the *Price* $\times$ *R&D Costs* interaction term is opposite that of *Price*, we conclude that *R&D costs* moderates (or attenuates) the effect of *Price* on takeoff times (e.g., see Baron and Kenny 1986). In other words, the speed of a price decline is an important determinant of sales takeoff times for innovations like radios, VCRs, and CD players that have relatively low costs of product improvements. For innovations like turbojet engines, cathode ray tubes, and piezoelectric crystals with relatively high R&D costs, sales takeoff times are not driven by price (but instead, product quality improvements are critical).[22]

4. Discussion and Implications

Three key findings emerge from our empirical analyses of the market evolution and takeoff of consumer and industrial product innovations.

(1) We find that sales and the number of competing firms for consumer and industrial product innovations exhibit an initial period of slow growth that is eventually followed by sharp takeoff.

(2) We find that the time between firm and sales takeoff varies considerably across products, and that a firm takeoff systematically occurs before the sales takeoff. This suggests that the market entry decisions of early entrants are based on expected sales rather than actual realized sales.

(3) We find strong evidence that firm entry into a new market dominates price reductions in explaining takeoff times. We interpret this result as supporting the idea that demand shifts during the early evolution of a new market due to nonprice factors is the key driver of a sales takeoff.

Our first finding adds to the limited empirical research on the takeoff phenomenon that has appeared in distinct literatures; i.e., evidence for a

[19] We thank an anonymous reviewer for suggesting these explanations.

[20] Similar conclusions are obtained for other measures of price lags, including time to a 5% reduction in price after takeoff and average price reduction one year after takeoff.

[21] Because we have specific hypotheses about the coefficient signs, we use one-tail significance levels in Table 5. The same basic conclusion is also obtained using two-tailed tests with a more "lenient" alpha level of 0.20 (see Stevens 1996 for a discussion of improving the power of statistical tests for small samples using higher alpha-level tests). See Boland et al. (2001) for a recent example that uses an 80% confidence level for analyses involving small samples.

[22] It is interesting to note that the correlation between *Price* and *New Firm Entry* is negative and significant for the 13 product innovations in our sample that were also analyzed by Golder and Tellis (1997). We further note that *R&D costs* for these 13 products are not significantly different from the other 17 products. These results suggest that price reductions may play a more important role for the consumer durables considered by Golder and Tellis (1997) than for the broader set of consumer and industrial product innovations we study.

sales takeoff is reported in Golder and Tellis (1997) and for a firm takeoff in Gort and Klepper (1982). Our second and third findings represent new empirical results that have not as yet been reported in the published literature. Our third finding is also good news for managers of product innovations because it suggests that sales growth does not have to necessarily come at the expense of compressed profit margins typically associated with declining prices.

Our findings add to the set of empirical regularities that have been reported in the literature (e.g., see the review in Klepper 1997). Based on our accumulated knowledge to this point, we speculate that the market evolution for a product innovation unfolds as follows. First, there is an initial discovery of a potential product innovation. Typically, a long incubation period ensues after the pioneering invention, which is eventually followed by the commercialization of various specific product forms by one or more small and/or large firms. Based on early competitive activity in the nascent market (e.g., the relative number of initial entrants that are small entrepreneurs or large corporations, the early entrants' level of success, etc.), potential entrants update their assessments of the benefits and risks associated with entry. As the new market evolves over time, competing firms collectively legitimize it to be a real opportunity. The number of firms competing in the new market then takes off as entrants rush in, anticipating large profits. As a result, supply-side capacity increases. Demand also increases due to the aggressive nonprice competition that occurs among incumbents and entrants in new oligopolistic markets; i.e., in the early stages of market evolution, fierce competition usually centers on demand-enhancing efforts such as R&D directed towards product improvements. Depending on the specific product innovation and the nature of its supply and demand curves, prices can decrease or increase. As a result of this competitive activity, consumers eventually legitimize the product innovation by accepting that it provides real benefits over existing products. Sales of the product innovation then take off. After the sales takeoff, both sales and the number of competing firms continue to increase but at a decreasing rate. Eventually, there is a shakeout of firms in the industry, and the number of competitors drops and then stabilizes. We note, however, that this "story" is speculative at this point because it has not been formally tested with a complete set of empirical data.

See Agarwal and Bayus (2002) for a more extensive discussion of the forecasting, modeling, and strategic implications of our results.

5. Future Research Directions

Although our results strongly suggest that nonprice competition associated with new firm entry rather than price decreases drives sales takeoff for product innovations, research involving other measures of product evolution and improvement should be conducted to confirm this finding. Furthermore, our results imply that models of new product sales need to explicitly account for the takeoff phenomenon and product evolution during the early stages of market development. Thus, for example, future research dealing with sales diffusion models (e.g., Bass 1980, Mahajan et al. 1990) and models of the evolution of new markets (e.g., Klepper and Graddy 1990, Jovanovic and MacDonald 1994, Klepper 1996) should make provisions to account for these findings. It is likely that such research will require additional theoretical modeling of the takeoff phenomenon.

Efforts by new entrants to increase sales may take many forms, including product improvements, promotional activities that educate consumers, and market infrastructure development associated with expanded distribution. While our results link new firm entry to sales takeoff, further research is needed to assess the importance of each of these demand-enhancing factors. For instance, as suggested by Brown (1981), the time between firm and sales takeoff for a product innovation may be related to the existence and evolution of a market infrastructure. This infrastructure can take different forms and might be established in various ways. Thus, it may be that the market infrastructure for a product innovation must be developed before a sales takeoff can occur, and perhaps occurs concurrently or ensues shortly after entry. This line of reasoning suggests that an important topic for future research is to empirically investigate the relationship between firm entry, market infrastructure development, and sales takeoff.

Our empirical results also indicate that competition is important to the market evolution and takeoff of product innovations. In particular, we find that a sharp increase in the number of competing firms in a new market precedes a sales takeoff and high firm entry rates are associated with quicker sales takeoffs. Thus, our results imply that a strategy of erecting entry barriers is not conducive to the market takeoff of a product innovation; i.e., monopolies dampen the growth of new markets. In addition, firms may be able to collectively influence the takeoff of a product innovation. Consequently, individual firm decisions on advertising expenditures, distribution policies, and product development (e.g., technology standards and cross-licensing policies) may influence their own brand sales as well as the growth rate of the total market. With an eye towards identifying the factors related to a swift sales takeoff, future research could thus empirically and analytically investigate the nature of firm alliances and collaborations during the formative stages of a new market.

Acknowledgments
The authors greatly appreciate the financial support of the Marketing Science Institute. They thank Darren Filson and Peter Golder for providing some of the data used, and the following people who commented on an earlier draft of this paper: Raj Echambadi, Steven Klepper, Don Lehmann, John Roberts, Bill Robinson, and Christophe Van den Bulte, as well as the seminar participants at Cornell, Illinois, London Business School, Purdue, U. Central Florida and UNC. The usual disclaimer applies.

Appendix Summary of Data Sources

Product	Sales & Price	Number of Firms
Sewing machine	BC, Brandon	Cooper
Automobile	MVMA	Smith
Phonograph record	BC, BLS	TR
Vacuum cleaner	DM	TR
Outboard engine	BC, BLS, Predicasts	TR
Electric blanket	DM	TR
Dishwasher	DM	TR
Radio	DM	Grinder
Clothes washer	DM	TR
Freon compressor	Predicasts	TR

(Continued)

Appendix Table Continued

Product	Sales & Price	Number of Firms
Cathode ray tube	EMDB, BLS, Predicasts	TR
Clothes dryer	DM	TR
Electric razor	DM	TR
Styrene	ITC	TR
Piezoelectric crystals	Predicasts	TR
Home freezer	DM	TR
Antibiotics	ITC	TR
Turbojet engine	AIAA	TR
Ballpoint pen	WIMA, BLS	TR
Garbage disposer	DM	TR
Magnetic recording tape	Predicasts	TR
Heat pump	Predicasts	TR
Computer printer	ITI, Filson	TR, Filson
Home microwave oven	DM	TR
Monitor	ITI, Filson	TR, Filson
Microcomputer	IDC	IDC
Home VCR	DM	TR, LNA
Compact disc player	DM	TR, LNA
Cellular telephone	DM	TR, LNA
Optical disc drive	Disk/Trend, Golder	TR

AIAA: Aerospace Industries Association of America, *Aerospace Facts and Figures*
BC: Bureau of the Census, *Census of Manufacturers* & *Annual Survey of Manufacturers*
BLS: Bureau of Labor Statistics, *Producer Price Index* (previous name: *Wholesale Price Index)*
Brandon: Brandon, R. (1977), *A Capitalist Romance*, New York: Lippincott Publishing
Cooper: Cooper, G. (1968), *The Invention of the Sewing Machine*, Washington DC: Smithsonian Institution
Disk/Trend: *Disk/Trend Report*
DM: *Dealerscope Merchandising* (previous names: *Merchandising*, *Merchandising Week*)
EMDB: *Electronic Market Data Book*
Filson: Professor Darren Filson, personal communication
Golder: Professor Peter Golder, personal communication
Grinder: Grinder, R. (1995), *The Radio Collector's Directory and Price Guide*, Chandler, AZ: Sonoran Publishing
IDC: International Data Corporation, *Processor Installation Census*
ITC: US International Trade Commission, *Synthetic Organic Chemicals: Production and Sales*
ITI: *Information Technology Industry Data Book*
LNA: Leading National Advertisers, *LNA/BAR Class/Brand YTD $*
MVMA: Motor Vehicle Manufacturers Association of US, *Motor Vehicle Facts & Figures*
Predicasts: *Predicasts Basebook*
Smith: Smith, P. (1968), *Wheels Within Wheels*, NY: Funk and Wagnalls
TR: *Thomas Register of American Manufacturers*
WIMA: Writing Instruments Manufacturers Association, *Mechanical Handwriting Instruments Industry*

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Accepted by Ralph Katz; received December 2000. This paper has been with the authors 4 months for 3 revisions.