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Creating Growth in New Markets: A Simultaneous Model of Firm Entry and Price*

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Sales in a new market generally follow a hockey-stick pattern: After commercialization, sales are very low for some time before there is a dramatic takeoff in growth. Reported sales takeoffs across products vary widely from a few years to several decades. Prior research identifies new firm entry or price declines as key factors that relate to the timing of a sales takeoff in new markets. However, this literature considers these variables to be exogenous and only finds unilateral effects. In the present article, new firm entry and price declines are modeled as being endogenous. Thus, the simultaneous relationship between price declines and firm entry in the introductory period of new markets when industry sales are negligible is studied. Using a sample of new markets formed in the United States during the last 135 years, strong support for a simultaneous model of price and firm entry is found: Price decreases relate to the competitive pressures associated with firm entry, and, in turn, firm entry is lower in new markets with rapidly falling prices. Furthermore, a key driver of firm entry during the early years of a new market involves the level of patent activity, and a key driver of price decreases is the presence of large firms. In contrast to the recommendations from other research, these results indicate that rapid price declines may further delay sales takeoff in industries by dampening new firm entry. Instead, rapid sales takeoffs in new markets come from encouraging greater innovative activity and the entry of large firms.

Introduction

The invention of a new product is only the beginning of what can be a long road to eventual widespread acceptance in the marketplace. For example, though personal computers were conceptualized in the 1950s, they became technologically possible only in the 1960s, and the first commercial product became available more than a decade later with the appearance of the Mark-8 Minicomputer and MCM-70 Microcomputer in 1974—the Altair 8800 was introduced in 1975. Even postcommercialization, only a few thousand units were sold in each year during the introductory period between 1974 and 1981 (Figure 1). Personal computer sales finally took off in 1982: Over 3 million units were sold in 1982, a 291% increase over the pervious year. Notably, industry, or real, prices were generally declining over this time period—average annual industry prices dropped by 20% each year between 1974 and 1982—and despite the relatively low levels of sales in the early years, the number of new entrants continued to rise in this new market.

The personal computer industry exemplifies the general patterns documented by prior research of the evolution in new markets (e.g., Agarwal and Bayus, 2002; Geroski, 2003; Golder and Tellis, 1997; Gort

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and Klepper, 1982; Kholi, Lehmann, and Pae, 1999; Klepper, 1997; Mensch, 1979; Utterback, 1994). An initial incubation period between the invention and commercialization of a new innovation is followed by an introductory period of low sales and industry growth. The number of firms competing in the new market is low at the beginning, and a surge in new firm entry occurs before the market enters its growth stage. Industry prices generally start high and then decrease over time. Table 1, for example, reports average annual sales penetration (where sales penetration is the ratio of annual unit sales to the observed peak sales) and average annual new firm entry (where new firm entry is the ratio of annual new entrants to the total number of competitors) during the introductory period for 30 new markets. Notable in Table 1, however, is the considerable cross-sectional variation in activity during the introductory period in new markets (Agarwal and Bayus, 2002). For some product innovations like compact disc players, cellular telephones, radios, and turbojet engines, a large fraction

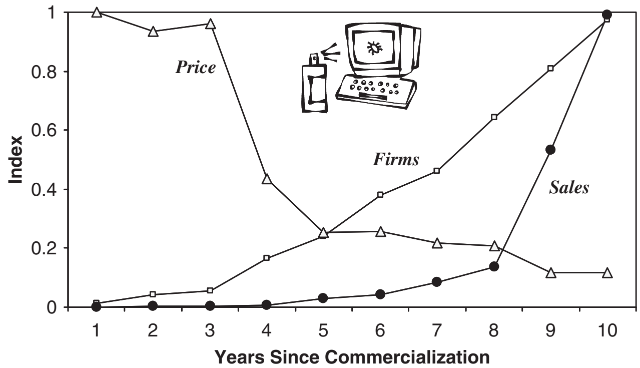

Figure 1. Evolution of the Personal Computer Industry (Source: International Data Corporation, Processor Installation Census)

of the competitors during the early years is new entrants. For others like dishwashers, electric blankets, and vacuum cleaners, relatively few firms entered during the initial years of the new market. Similarly, the rate of price declines varies significantly across markets, with some innovations actually having an increase in prices. For example, given dramatic increases in the quality of turbojet engines, prices actually increased during the early years after commercialization.

The received literature on the period before sales takeoff emphasizes new firm entry (e.g., Agarwal and Bayus, 2002; Geroski, 2003; Klepper, 1997) or declining prices (Golder and Tellis, 1997) as key factors affecting the likelihood of sales takeoff. However, these studies assume that new firm entry and prices are exogenous and only find unilateral effects. In fact, the distinction and importance of exogenous versus endogenous variables has been the subject of extensive discussion (Engle, Hendry, and Richard, 1983), concluding that any empirical analyses are conditional on the validity of the relevant exogeneity assumptions. That is, not properly accounting for endogeneity can lead to incorrect conclusions about the role and importance of any explanatory variables. Thus, the published results fail to provide a complete explanation for the key phenomenon during the introductory period of a new industry when sales are negligible. Further, the cross-sectional variation in these variables just discussed highlight the need to delve deeper into the workings of this early entrepreneurial period. Extant explanations for firm entry and price declines generally relate to established industries (Geroski, 1995) rather than to newly introduced markets. For example, even though a positive relationship between firm entry and lagged industry profitability has been found, these results cannot be directly applied before

BIOGRAPHICAL SKETCHES

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Table 1. Characteristics of New Markets during the Introductory Period

New Market	Introductory Period	Average Annual Sales Penetration	Maximum Number of Firms	Average Annual New Firm Entry
Sewing Machine	1849–1858	0.074	40	0.23
Automobile	1890–1908	0.003	233	0.24
Phonograph Record	1897–1918	0.019	13	0.17
Vacuum Cleaner	1911–1933	0.010	20	0.13
Outboard Engine	1913–1935	0.054	23	0.11
Electric Blanket	1915–1951	0.075	13	0.06
Dishwasher	1915–1944	0.053	10	0.05
Radio	1919–1922	0.005	42	0.67
Clothes Washer	1921–1932	0.117	32	0.21
Freon Compressor	1935–1963	0.206	19	0.09
Cathode Ray Tube	1935–1948	0.093	14	0.22
Clothes Dryer	1935–1949	0.019	14	0.12
Electric Razor	1937–1942	0.092	33	0.35
Styrene	1938–1945	0.001	6	0.29
Piezoelectric Crystals	1941–1972	0.147	35	0.10
Home Freezer	1946–1949	0.168	39	0.53
Antibiotics	1948–1955	0.040	16	0.42
Turbojet Engine	1948–1950	0.364	6	0.64
Ballpoint Pen	1948–1957	0.113	5	0.18
Garbage Disposer	1949–1954	0.072	11	0.38
Magnetic Recording Tape	1952–1967	0.118	36	0.22
Heat Pump	1954–1975	0.085	24	0.15
Computer Printer	1960–1978	0.018	74	0.16
Home Microwave Oven	1970–1975	0.031	12	0.37
Monitor	1971–1980	0.194	69	0.40
Personal Computer	1974–1981	0.018	93	0.40
Home VCR	1974–1979	0.020	6	0.29
Compact Disc Player	1983–1984	0.004	8	0.81
Cellular Telephone	1983–1985	0.004	26	0.65
Optical Disc Drive	1984–1992	0.008	38	0.24

sales takeoff since a relatively large number of firms rush in before lagged profits and sales are substantial (see Figure 1). Thus, there exist research gaps related to the modeling of new firm entry and price declines as being potentially endogenous as well as the implications of these endogenous factors on sales takeoff. Additional insights into this phenomenon can lead to more effective firm decisions that hasten the growth of new markets.

The cross-sectional variation in firm activity during the early years of a new market in which sales are relatively low is studied. In contrast to the existing literature, the present article provides substantive insights into firm behavior behind the growth of new markets. Importantly, this study departs from previous research that considers firm behavior to be exogenous (Agarwal and Bayus, 2002; Golder and Tellis, 1997; Gort and Klepper, 1982). Instead, in the spirit of Moore, Boulding, and Goodstein (1991) a simultaneous system of equations in which new firm entry and price are endogenous factors is proposed. Empirically studying the introductory period of 30 consumer and industrial innovations that were commercialized in the United States during the last 135 years, feedback effects between price declines and new firm entry are found: Price decreases are related to the competitive pressures associated with firm entry, and, in turn, firm entry is lower in new markets with rapidly falling prices. In addition, the level of innovative opportunity in the new market—that is, growth in patent stock—is identified as a key driver of new firm entry, and the presence of large firms is shown to be a key driver of price decreases. Thus, prior research in this area is extended by providing an explanation for factors that determine sales takeoff such as new firm entry (Agarwal and Bayus, 2002) or price declines (Golder and Tellis, 1997). The results in the present article highlight a potential problem of prescriptions from extant work. For example, in contrast to Golder and Tellis (1997), the present study implies that firms should not reduce prices too quickly in new markets. Unlike Agarwal and Bayus (2002), the simultaneous model in the present article allows an explanation: Lower prices lead to less firm entry, which in turn leads to longer sales takeoff times.

The next section provides a brief overview of existing literature on the determinants of sales take-off, with the intent of identifying existing research gaps. Then a theoretical framework for firm entry and price declines in new markets when sales are minimal is developed. The data and variables used in the empirical study are then described, after which the set of equations that form the empirical model is presented and the estimation results discussed. To explicitly link the model and results with the existing literature, the relationship between new firm entry, price, and the length of the introductory period in a new market (i.e., the sales takeoff time) is then explored. Finally, conclusions and suggestions for further research are given.

Research Positioning

The emergence stage of new product markets has been systematically studied in only a few prior studies (Agarwal and Bayus, 2002; Golder and Tellis, 1997; Gort and Klepper, 1982). These efforts are briefly reviewed to address both their contributions to understanding the industry life cycle prior to sales takeoff and to identify research gaps that exist in the literature. Table 2 provides a summary of the key findings.

The pioneering work by Gort and Klepper (1982) highlights the evolutionary pattern in the number of firms that enter and compete in a new market. Using data on 46 consumer and industrial product innovations, they depict the diffusion of innovations over time in terms of distinguishable stages. Importantly, they find an association between the type and rate of innovation undertaken in the market and the rate of firm entry in a new industry. Though the emergence stage is not a primary focus of their study, Gort and Klepper set the stage for future efforts to investigate whether market takeoff times may be systematically determined based on key firm and industry characteristics.

Golder and Tellis (1997) delve deeper into the issues related to sales takeoff in new product markets, with a focus on whether the timing of sales takeoff can be predicted. By studying 31 consumer durable innovations, their key finding is that price declines lead to shorter sales takeoff times, with the implication that firms interested in achieving sales takeoff in new markets should strive to encourage demand by reducing prices. Agarwal and Bayus (2002) examine the same issue but instead take a primarily supply-side perspective. Though acknowledging the effect of price decreases on sales takeoff, their study of 30 consumer and industrial product innovations focuses on the role of new firm entry in determining the timing of sales takeoff. Noting that firm takeoff systematically precedes sales takeoff, they find that higher rates of new firm entry lead to shorter sales takeoff times.

Though the results of these prior studies seem intuitively appealing, they raise several issues that have not been currently addressed in the literature. In particular, prior work has failed to address why prices decrease prior to sales takeoff or why firms enter a new market when sales are negligible. Though the results found by Golder and Tellis (1997) may be attributed to downward sloping demand curves, their findings beg the question of what causes prices to decline. It is not clear from their framework if price declines occur due to monopoly profit maximization behavior in the early stages of a new market or due to competitive pressures unleashed by firm entry. The findings by both Gort and Klepper (1982) and Agarwal and Bayus (2002) seem to suggest that it may be the latter phenomenon, but neither study explicitly addresses the causal aspects of the firm behavior prior to sales takeoff. Further, their work fails to address why firms enter prior to the sales takeoff and why the impact of price declines on their entry decisions.

There are two important limitations of prior research addressed in the present article: (1) Previous studies examine each major determinant of sales takeoff largely in isolation of the other and treat them as exogenous factors; and (2) by doing so, these studies fail to incorporate feedback effects of one factor on the other. The present study contends that such a research design may lead to erroneous implications for firm strategy. Indeed, sales takeoff may occur as a simultaneous consequence of the interaction between firm entry and price declines over time, thus requiring that the key variables be examined in a simultaneous model setting. Doing so also allows other key factors—such as innovative activity and entry by large firms—that are related to sales growth in new markets to be identified.

Theoretical Framework

Figure 2 provides an overview of the theoretical framework underlying the present study. The existing literature is used to develop hypotheses related to firm

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Table 2. Summary of Related Research and Contributions

	Gort and Klepper (1982)	Golder and Tellis (1997)	Agarwal and Bayus (2002)	Present Study
Key Research Question(s)	What is the pattern of firm entry over the product life cycle?	What are the characteristics of the sales takeoff? Can the sales takeoff be predicted?	What are the roles of price decreases and new firm entry in explaining the sales takeoff?	Why do firms enter a new market before sales take off? Why do prices decrease before sales take off?
Endogenous Variable(s)	N/A	Sales Takeoff Time	Sales Takeoff Time	New Firm Entry; Price; Sales Takeoff Time
Primary Exogenous Variable(s)	Firm Entry; Innovation Activity; Price	Price	New Firm Entry; Price	Innovative Opportunity; Required Development Resources; Presence of Large Firms
Data	46 consumer and industrial product innovations	31 consumer durable innovations	30 consumer and industrial product innovations	30 consumer and industrial product innovations
New Findings	Firm entry into new markets follows a diffusion pattern with distinguishable stages. There seems to be an association between rises and declines in the rate of innovation and the rate of entry into new markets.	Price declines lead to shorter sales takeoff times.	Firm takeoff systematically occurs before the sales takeoff. Higher new firm entry leads to shorter sales takeoff times.	Price and innovative opportunity drive firm entry into new markets. New firm entry and the presence of large firms drive price declines in new markets.
Important Implications	Market takeoff times can be systematically determined.	Firms should strive to reduce prices in new markets.	Firms should encourage competition in new markets.	Firms should not quickly reduce prices in new markets—lower prices lead to less firm entry, which in turn leads to longer sales takeoff times. Innovative activity and the entry of large firms should be encouraged.

entry and price declines in this section. Unlike prior research, which has generally studied these hypotheses in isolated situations, these hypotheses are incorporated into a simultaneous equations model in which new firm entry and price changes are endogenous factors (Figure 2). The present authors are unaware of any similar simultaneous model for either new or established markets.

Why Do Firms Enter a New Market?

Despite the difficult nature of quantifying expected profitability, several studies document a positive relationship between firm entry, past industry profitability and industry growth rates (see, e.g., Acs and Audretsch, 1990; Geroski and Schwalbach, 1991; Orr, 1974). In a recent paper, Debruyne and Reibstein (2005) find that contagion effects between firms is a significant predictor of an incumbent's entry timing into a related submarket. In other words, an incumbent firm with a product is influenced by the number of like firms entering the new, related market in making its own entry decision. This is not the situation studied in the present article, which instead centers on examining cross-sectional variation in firm entry across new markets.

In new industries, however, many firms enter well before sales—or profits or industry growth—reach substantial levels (Figure 1). Thus, conventional variables like current or lagged profitability and industry growth rates will not be effective measures of the expected profit potential associated with a new industry. Instead, it is argued that the profit potential associated with a new market is signaled by factors such as innovative activity, development costs, and price declines. Each of these is discussed in turn.

Prior research emphasizes significant cross-sectional variation in innovative opportunities across markets, either due to innovative potential or to demand conditions (e.g., Mansfield, 1968; Schmookler, 1966). As noted by Gort and Klepper (1982), Geroski (1989), and Acs and Audretsch (1990), industries with high levels of innovative activity tend to have high entry rates. Another possible hypothesis is that innovative activity increases the barriers to entry due to patenting and the protection of intellectual property (see, e.g., Church and Ware, 2000). However, studies have found that the spillovers of knowledge created due to innovative activity enable rather than limit entry (e.g., Arrow, 1962; Blair, 1972; Geroski and Pomroy, 1990). This is also consistent with empirical studies that find significant entry, even in capital-intensive industries where scale economies are important (Acs and Audretsch, 1990; Audretsch, 1995; Smiley, 1988). For new markets, entry barriers also seem to be inconsequential since a number of both small and large firms enter most markets well before substantial sales are achieved (Agarwal and Bayus, 2002; Geroski, 2003).

For the early period of new market formation before sales takeoff, there are several reasons for new firm entry to be positively affected by high levels of innovative activity. On the demand side, new entrants may perceive a higher profit potential in new markets with high levels of innovative opportunities due to greater prospects for product differentiation and niche marketing (Baldwin, Hanel, and Sabourin, 2002; Blair, 1972; Comanor, 1967). In addition, high innovative opportunities can lead to the resolution of uncertainty about consumer preferences for product features. Any resulting positive word of mouth can, in turn, increase the perceived profit potential associated with the innovation. Similarly, on the supply side uncertainty related to the technical means of satisfying these desires make it difficult for a potential entrant to accurately assess the profits associated with a new market (Abernathy and Utterback, 1978; Clark, 1985; Klepper, 1997). Resolution of this uncertainty takes time and typically occurs as new firms innovate (Adner and Levinthal, 2001; Klepper, 1997; Mueller and Tilton, 1969). In new markets, high innovation rates usually mean that the key product specifications will be defined and any technical issues will be quickly worked out (e.g., Greve and Taylor, 2000). Thus, both demand and supply considerations suggest that the perceived profit potential and resultant firm entry are likely to be higher in markets with higher levels of innovative opportunity. Here, the underlying cross-sectional variation in technologies and demand conditions

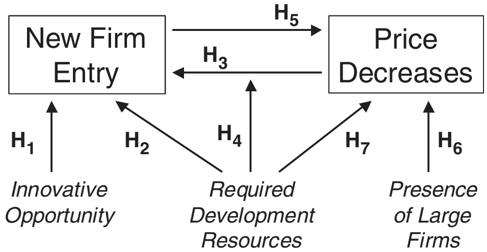

Figure 2. Theoretical Framework

that lead to different levels of innovative activity is emphasized, acknowledging that some firms innovate prior to entering a market (e.g., diversifying entrants) whereas other firms innovate after entering. Regardless of when firms undertake the innovative activity, the perceived profit potential for entrants is higher in markets with high innovative activity. As a result, the following hypothesis is proposed.

H1: Firm entry is higher in new markets with higher levels of innovative opportunity.

The profit potential of a new market is negatively related to entry costs like advertising and research and development (R&D) expenditures (Sutton, 1991, 1998). A fundamental premise of the industrial organization literature is that entry costs are a critical determinant of firm entry (e.g., Church and Ware, 2000; Sutton 1991, 1998). Though the strategic use of these investments to deter entry is not emphasized (e.g., Dixit, 1980), it is expected that a firm's entry decision will be influenced by whether large capital outlays on advertising, R&D, and the development of new infrastructure and complementary products are necessary to compete in the new industry (Acs and Audretsch, 1990; Adner and Levinthal, 2001; Brown, 1981; Orr, 1974; Tripsas, 1997). Nascent industries vary in their basic development requirements (e.g., Abernathy and Utterback, 1978; Acs and Audretsch, 1990; Agarwal, 1998; Agarwal and Bayus, 2002). For example, success—and survival—in industries like turbojet engines (Constant, 1980) or pharmaceuticals (Gambardella, 1995) demand higher than average R&D investments since continued product improvements rely on advancements in basic science and technology. Not surprisingly, some firms find these entry costs to be a strong deterrent. Thus, the following hypothesis is proposed.

H2: Firm entry is lower in new markers that require higher development costs.

The profit potential of a new market is also determined by industry prices; that is, falling prices in a new market will generally signal reduced profit opportunities (Geroski, 1995, 2003; Lambkin and Day, 1989). Following Agarwal and Bayus (2002), the early periods of new markets are characterized by outward shifting demand and supply curves. Though sales increases in such circumstances, traditional economic theory suggests that the effect on price is indeterminate. If prices stay stable—or even increase—the profit potential remains high. Falling prices, on the other hand, signal to potential entrants that price skimming strategies—traditionally employed by firms due to the differences in price sensitivity across consumers (e.g., Dean, 1976; Rogers, 1995)—are being used by existing firms and that strong competitive pressures are already at work in the market. The more rapidly prices decline in a new market, the lower is the incentive to enter. Accordingly, the following hypothesis is proposed.

H3: Firm entry is lower in new markets with more rapidly declining prices.

In addition, research suggests that H3 may be moderated by the required development resources (e.g., Acs and Audretsch, 1990; Agarwal and Bayus, 2002; Audretsch, 1995). In markets with rapidly declining prices, firms may still be willing to enter if they believe that the revenue–cost differential is sufficiently high due to low development costs. In markets requiring relatively high development expenditures, firms may be willing to enter if they can expect price stability to offset the additional costs. On the other hand, it is expected that potential entrants will perceive that there are considerably lower available profits in new markets requiring both high development costs and rapidly declining prices due to the dual pressures on the anticipated profits. As a result, the following interaction hypothesis is proposed.

H4: In new markets with rapidly declining prices, firm entry in markets requiring higher development costs is lower than in markets requiring lower development costs.

Why Do Prices Decrease in New Markets?

Unfortunately, the existing literature does not provide an internally consistent explanation for declining prices in the early years of a new market when sales are minimal (e.g., Lambkin and Day, 1989). For example, it has analytically been shown that optimal new product prices decline over time when demand approaches the market saturation level (e.g., Kalish, 1988) or that marginal costs decrease over time due to the experience effects associated with increasing cumulative volume (e.g., Kalish, 1988; Krishnan, Bass, and Jain, 1999). However, both of these conditions require sizeable sales levels before prices significantly drop.

Several studies note that during the early, formative stages before sales takeoff, the customer base is generally composed of innovators and early adopters who are willing to pay higher prices than other consumers (e.g., Dean, 1976; Rogers, 1995). However, the ability of an existing firm to engage in a price-skimming strategy is dependent on the competition it faces. Though a monopoly strategy may be to reduce prices only to the extent that marginal revenue brought in by the more price sensitive consumers equals the additional costs, the presence of other firms will prevent this from occurring. Thus, the more competitors in a new market, the greater are the competitive pressures to decrease prices (e.g., Klepper, 1997; Lambkin and Day, 1989; Mueller and Tilton, 1969). Therefore, the following hypothesis is proposed.

H5: Prices decline faster in new markets with higher firm entry.

Due to economies of scale, large firms have many potential costs advantages over small firms (Church and Ware, 2000). To the extent that a new market has many large firms, there may be greater benefits based on increases both in cumulative production experience and scale economies (e.g., Cohen and Klepper, 1996; Gort and Klepper, 1982). For example, the initial manufacturing of a new product is often accomplished on unspecialized machinery that can be very cost inefficient at low volumes of production (see, e.g., Geroski, 2003; Klepper, 1997). The presence of large firms enhances the effect of learning curves and economies of scale; additionally, large firms have lower costs associated with their financial transactions (e.g., lower interest rates), enabling them to acquire specialized capital and employ specialists that can lead to further increases in efficiency. These lower costs can then be translated into price declines to attract new customers or increase sales to the existing customer base. Consequently, the following hypothesis is proposed.

H6: Prices decline faster in new markets with more large firms.

Due to the relative primitiveness of the first products in a new market, significant development resources may be called for to fully meet customer demands (e.g., Agarwal and Bayus, 2002; Klepper, 1997). New markets may also require extensive advertising and promotion to educate and inform potential customers about the benefits of the new innovation (e.g., Brown, 1981). Widespread adoption of product innovations can also require the development of complementary products and services (Shocker, Bayus, and Kim, 2004). In such situations, a price-skimming strategy is often employed where prices are kept high to recover development expenses (Bensanko and Winston, 1990; Dean, 1976; Klepper, 1996; Nagle and Holden, 2002). In other words, new markets that require a lot of development resources should have prices that do not rapidly fall over time. Hence, the following hypothesis is proposed.

H7: Prices decline faster in new markets that require fewer development resources.

Data and Variables

In this section, the data and key variables available are described. Though the 30 innovations in the present study come from Agarwal and Bayus (2002), new data on patents and firm size were collected especially for this study. This set of innovations was constructed from various sources including scientific journals, chronologies, and encyclopedias of new inventions. To be included, a consumer or industrial product innovation had to be deemed significant by experts in the field and result in an entirely new industry rather than simply be an improvement or minor subsection of an existing market. This set includes a diverse mix of important consumer and industrial innovations introduced in the United States between 1849 and 1984 that vary in their capital and technological intensiveness, and the set overlaps with those studied by other researchers (e.g., Golder and Tellis, 1997; Gort and Klepper, 1982). Many of these innovations were introduced between 1905 and 1966, which is generally believed to be the most technologically progressive period in U.S. economic history (Abramovitz and David, 2000; Field, 2003; Gordon, 2000). A set of consistent time-series data on the key variables was compiled. Based on information reported in Agarwal and Bayus (2002), the introductory periods for each market are defined to be the time between commercialization and the year before the sales dramatically increases, that is, the sales takeoff (Table 1).

Following related research (Agarwal and Bayus, 2002; Golder and Tellis, 1997; Gort and Klepper, 1982), only successful innovations are considered. Note, however, that the possible concern from this approach is somewhat mitigated by the fact that innovations historically exhibit a wide variation in length of the introductory period. Since several products in the sample take well more than 20 years before entering the growth stage (Table 1), innovations that could have been considered failures based on their very low sales in the early years are included in the sample. Thus, it is very difficult to distinguish whether a new market is a failure or if the market has been observed long enough. For example, based on its negligible sales in the 1920s—more than 10 years after its commercialization in 1911—the electric vacuum cleaner would have been deemed a failure if this data set was being assembled in 1925: Vacuum cleaner sales actually took off 23 years after its commercialization (Table 1).

In addition, the potential effects due to sample selection bias were explicitly considered by using a standard Heckman (1979) two-step Probit model (details are available from the authors). To do this, the present study's sample of innovations was split into two groups based on the length of the introductory period as well as the magnitude of sales takeoff. Results indicate that the sample selection bias correction term (inverse Mills ratio) is not significant and, more importantly, that the conclusions reported in this article are robust.

Annual data were gathered for these 30 new markets from a variety of published sources. This information was then used to construct a cross-sectional data set for analysis purposes. The key variables in this study, their definitions, and descriptive statistics are shown in Table 3.

Data for sales and average price were compiled from various sources used by other researchers (see, e.g., Agarwal and Bayus, 2002; Golder and Tellis, 1997), including *Dealerscope Merchandising* and *Predicasts Basebook*. The annual prices for each product were deflated by the consumer price index (consumer products) or the producer price index (industrial products) to account for inflation and general productivity changes in the economy.

Information on the commercialization date, entry, exit, and number of competing firms in any given year were primarily compiled from the *Thomas Register of American Manufacturers*, a source that has been used to study firm activities in new industries (Agarwal and

Table 3. Variable Definitions and Descriptive Statistics

Variable	Definition	μ (σ)
ΔPrice	Changes in price, measured as the estimated coefficient η from fitting a linear time trend ($\phi + \eta t$) to the log of the price series to the year before the end of the introductory period (see Agarwal and Bayus, 2002; Bayus, 1993)[a]	−0.06 (0.14)
New Firm Entry	Average annual ratio of new entrants to the total number of competitors between commercialization and the year before the end of the introductory period (see Agarwal and Bayus, 2002)	0.30 (0.20)
Large Firms	Average annual proportion of large firms present between commercialization and the year before the end of the introductory period	0.87 (0.14)
Patent Stock	Change in new patent applications, measured as the estimated coefficient θ from fitting a linear time trend ($\lambda + \theta t$) to the log of cumulative number of new patent applications to the year before the end of the introductory period (see Anderson, 2001)[b]	0.29 (0.22)
R&D Costs	Average industry R&D expenditures as a percentage of sales (see Agarwal and Bayus, 2002)	4.92 (3.34)
Year	Commercialization year	1939.83 (30.11)

[a] Other measures such as the percentage change in price during the introductory period and a ratio of the price in year prior to the end of the introductory period to the initial price at commercialization were also considered (see, e.g., Golder and Tellis, 1997). However, as suggested by the price pattern in Figure 1, none of these alternative measures adequately captures the nature of the observed price trend. Because the interest of the present study is in an analysis of price trends across new markets, a single parameter that measures changes over the entire introductory period is most desirable. This is consistent with the approach of fitting an exponentially declining time trend.

[b] Cumulative patents follow an S-shape pattern over the entire product life cycle (Anderson, 2001). Because cumulative patents exhibit an exponentially increasing pattern over time during the introductory period, log(cumulative patent applications) is used. This approach also allows for the control of other effects such as *Year* and industry type, that is, $\lambda_1 + \lambda_2$ *Year* + Industry Dummies[$\lambda_3 + \theta$ t].

Bayus, 2002; Gort and Klepper, 1982; Klepper, 1997; Robinson and Min, 2002). Firm listings were subjected to several checks to ensure actual market entry rather than a renaming or relocation (Agarwal, 1997).

To gauge firm size, the asset size class categories reported in the *Thomas Register* were used to identify large firms. *Large firms* are defined to be those with assets greater than US$1.4M (in 1982 dollars) at the turn of the century, and over time, consecutive asset categories were added to the definition to appropriately adjust for inflation.

Following numerous studies (e.g., Acs and Audretsch, 1989; Agarwal, 1998; Gort and Klepper, 1982), information on patent activity was used to quantify the level of innovative opportunity in a new industry. Due to the nontrivial costs involved, this research considered that patenting activity might also be a signal of firms' belief that the new market holds much profit potential. In this case, it would be expected that price and patenting activity are highly correlated (from H1). However, there is no evidence to support this supposition since the correlation between *Price* and *Patent Stock* is only 0.10 and insignificant ($p = .60$). This article also recognizes that there are several well-known problems with patent data (Griliches, 1990), for example, not all innovations are patentable and not all patentable inventions are patented. Though different patent strategies and propensities to patent across firms can be problematic, studies have shown that patenting activity strongly correlates with the underlying technological opportunities in an industry. Despite its limitations, patent information has thus become a mainstay of technological studies (e.g., Jaffe and Trajtenberg, 2002). Thus, the proxy for innovative opportunity in this study is based on annual counts of patents granted by the U.S. Patent and Trademark Office, available on their Web site (www.uspto.gov). Due to varying administrative and legislative delays between the application and granting of a patent, patent application dates are used (e.g., Basberg, 1987). Consequently, information on the patent applications for each innovation in the sample that ultimately led to patent grants was compiled. The class and subclass definitions used for each new market in the sample are available on request. Since full-text search is only available for patents issued since 1976, manual searches of individual full-page images were used to determine the application dates for each patent application before 1976. Due to the large number of patents for some classes and subclasses, a random sample of annual patents was used to estimate the patent stock distribution for five industries: automobile, dishwasher, computer printer, radio, and sewing machine. As a robustness check, all of the models used in the present study were also estimated using only the 25 industries with complete data. The empirical conclusions in this article remain unchanged. The patent stock for an innovation in any year is the cumulative number of patent applications since that product was commercialized (Anderson, 2001).

As a proxy for required development resources in a new industry, Agarwal and Bayus's (2002) steady-state measure of *R&D Costs* was used and calculated as average R&D expenditures as a percentage of sales for each innovation in the sample using National Science Foundation data (NSF, 1999). Although this crude measure does not capture the full range of possible development activities that might be required for a new industry (e.g., advertising and promotion, new channels, complementary products and services), it represents the best set of consistent and quantitative data that are available. Further, note that the mean *R&D Costs* in the sample (4.92) is not statistically different from the mean *R&D Costs* across all U.S. industries (4.67), indicating that the present sample does not overrepresent high-technology industries.

Controls for systematic changes that may have occurred in the underlying structural conditions over time is accounted for by including commercialization year, *Year*, in each equation (e.g., Agarwal and Bayus, 2002; Audretsch, 1995; Golder and Tellis, 1997; Highfield and Smiley, 1987). Consistent with Golder and Tellis (1997) and Agarwal and Bayus (2002), other environmental variables such as World Wars (dummy variable), Great Depression (dummy variable), and gross national product were not significant and thus are not reported here.

Before developing the statistical models, the causal direction between key measures was carefully considered. For brevity, the details are not reported here (but are available from the authors). In particular, there is significantly higher growth in patent activity before as compared to after the number of firms competing in a new market dramatically increases ($t_{before-after} = 7.72$; $p < .01$). This suggests that patent activity leads to firm entry and not vice versa. In addition, the standard approach of constructing temporally lagged explanatory variables is also employed; that is, explanatory variables are measured at the year before the end of the introductory period (Table 3).

Empirical Model and Estimation Results

Based on the previous discussion, *New Firm Entry* and *ΔPrice* are considered to be endogenous variables that form the following set of simultaneous equations.

$$New\ Firm\ Entry = \alpha_1 + \alpha_2 \Delta Price + \alpha_3 Patent\ Stock + \alpha_4 R\&D\ Costs + \alpha_5\ R\&D\ Costs \times \Delta\ Price + \alpha_6\ Year + \varepsilon_1. \quad (1)$$

$$\Delta\ Price = \beta_1 + \beta_2\ New\ Firm\ Entry + \beta_4\ Large\ Firms + \beta_5\ R\&D\ Costs + \beta_6\ Year + \varepsilon_2. \quad (2)$$

In specifying equations (1) and (2), whether *Patent Stock*, *R&D Costs*, and *Large Firms* are indeed exogenous in the *New Firm Entry* and *ΔPrice* equations was considered. To statistically test for the endogeneity of these variables, Spencer and Berk's (1981) specification test was used. Following Hausman's (1978) suggested test procedure, the null hypothesis that *Patent Stock* ($F(2, 47) = 1.10$; $p = .342$) in the *New Firm Entry* equation is exogenous cannot be rejected; the same conclusion is reached for *R&D Costs* ($F(5, 44) = 0.83$; $p = .538$) and *Large Firms* ($F(4, 45) = 0.72$; $p = .581$) in the *New Firm Entry* and *ΔPrice* equations. As a result, *Patent Stock*, *R&D Costs*, and *Large Firms* were treated as being exogenous and used as instruments for *ΔPrice* and *New Firm Entry*.

To estimate equations (1) and (2), the standard instrumental variables (two-stage least squares) econometric procedure was employed (see, e.g., Greene, 2000). First, estimates for *New Firm Entry* and *ΔPrice* were constructed using a set of available instruments. The instruments used were *Patent Stock*, *R&D Costs*, *Large Firms*, *Large Firms* × *R&D Costs*, and a dummy variable indicating when *ΔPrice* was negative. These estimated values could then be separately used as independent variables in the appropriate equation (e.g., the instrumented *ΔPrice* variable was used in the *New Firm Entry* equation). Estimating this set of simultaneous equations using three-stage least squares to account for the possibility of correlated errors between the equations generated no additional insights over those reported here.

Table 4 reports the results of the instrumental variables estimations for *New Firm Entry* and *ΔPrice*. As indicated by the adjusted R^2 values and significant F-statistics, these two equations fit the data very well (system-weighted $R^2 = 0.743$; mean square error $= 0.974$). All of the key explanatory variables are statistically significant and consistent with the hypotheses. From the *New Firm Entry* equation, strong support for H1 through H4 is obtained. In other words, (1) new markets with lower potential profits (e.g., rapidly declining prices, requiring high development costs) have relatively lower firm entry rates; and (2) new markets with a lot of innovative activity (e.g., rapidly increasing patent stocks) have relatively high firm entry rates. The positive and significant coefficient estimate for *Year* indicates that new firm entry is generally higher for innovations commercialized more recently. From the *ΔPrice* equation, support for H5 through H7 was found. These results suggest that (1) new markets with competitive pressures due to high entry have rapidly falling prices; (2) new markets requiring high development costs do not have sharply declining prices; and (3) new markets with many large firms have quickly declining prices.

Whether prices are a function of cumulative sales was also examined—that is, whether prices decline due to learning or experience curve effects. Prices were found to not be related to sales volume during the introductory period; as expected, however, prices were significantly related to log(cumulative sales) afterward in the growth stage.

Implications for the Sales Takeoff Time

In this section, the results are linked to those of Golder and Tellis (1997) and Agarwal and Bayus (2002), in which new firm entry and price were considered to be

Table 4. Two-Stage Least Squares Estimation Results[a]

Variable	Expected Sign	Estimates
New Firm Entry		
Patent Stock	+ H1	0.957* (0.122)
R&D Costs	– H2	–0.017** (0.007)
ΔPrice	+ H3	1.167** (0.474)
R&D Costs × *ΔPrice*	– H4	–0.135** (0.050)
Year		0.002** (0.001)
Adjusted R^2 (F-statistic)		0.774 (20.82*)
ΔPrice		
New Firm Entry	– H5	–0.436** (0.174)
Large Firms	– H6	–0.662* (0.388)
R&D Costs	+ H7	0.014*** (0.007)
Year		–0.001 (0.001)
Adjusted R^2 (F-statistic)		0.410 (6.04*)

[a] Standard errors in parentheses.
* Significant at .01 level.
** Significant at .05 level.
*** Significant at .10 level.

exogenous factors related to the sales takeoff time (i.e., the length of the introductory period). Following these researchers, a proportional hazards regression model was used to estimate the conditional probability of a sales takeoff. Letting $h(t)$ be the hazard rate function of sales takeoff and $\gamma_1(t)$ be an arbitrary and unspecified baseline hazard function, the timing of a sales takeoff is specified as

$$\log h(t) = \gamma_1(t) + \gamma_2 \Delta Price + \gamma_3 New\ Firm\ Entry + \gamma 4\ Market\ Penetration + \gamma_5\ R\&D\ Costs + \gamma_6\ R\&D\ Costs \times \Delta Price + \gamma_7\ Year. \quad (3)$$

Equation (3) includes several controls for *Year*, *Market Penetration* (Golder and Tellis, 1997), *R&D Costs*, and the interaction term *R&D Costs* × *ΔPrice* (Agarwal and Bayus, 2002). A measure of market penetration was included in equation (3) to incorporate diffusion, or contagion, effects. Because the sample included consumer as well as industrial innovations, a *Market Penetration* index was constructed as the ratio of cumulative sales at the year before sales takeoff to the observed peak sales. To take into account the endogeneity of *New Firm Entry* and *ΔPrice* in equation (3), the estimated values from equations (1) and (2) were used.

The parameters in equation (3) were estimated using the partial likelihood method in the SAS PHREG procedure with the EXACT method to handle the tied events times (Allison, 1995). Table 5 contains the estimation results for our proportional hazard analyses. McFadden's (1974) likelihood ratio index, ρ^2—which for the present study's models is the same as the U^2 measure discussed by Hauser (1978)—is used as a measure of model fit ($0 \leq \rho^2 \leq 1$). The likelihood ratio index is calculated as $1 - L(x)/L_0$, where $L(x)$ is the log likelihood of the model with covariates and L_0 is the null model. As indicated by the ρ^2 values and significant chi-square statistics, this model fits the data in the present study very well. Overall, strong support that *New Firm Entry* is positively related to the hazard rate of sales takeoff is found; that is, new industries with high entry rates experience relatively quick sales takeoffs. Faint evidence that *ΔPrice* or *Market Penetration* is directly related to the timing of a sales takeoff is found.

Although the results of this study indicate that the direct relationship between *ΔPrice* and sales takeoff is weak, the endogenous nature of *ΔPrice* and *New Firm Entry* suggests that *ΔPrice* also indirectly influenced the sales takeoff time through *New Firm Entry*. In addition, the exogenous factors *Patent Stock*, *Large Firms*, and *R&D Costs* had indirect effects on the sales takeoff time through *New Firm Entry* and *ΔPrice*. To explore the relative impact of these exogenous factors on sales takeoff times, the estimation results reported in Tables 4 and 5 were used to conduct a sensitivity analysis of the effects associated with changes in the mean of each variable separately.

For this analysis, *Patent Stock*, *Large Firms*, and *R&D Costs* were systematically or exogenously varied, holding all other variables fixed. *ΔPrice* and *New Firm Entry* were then calculated using the estimates in Table 4. Next, the expected time to sales takeoff is calculated using the estimates of equation (3) in Table 5 (model 4) with the newly updated *ΔPrice* and *New Firm Entry* values. Following Golder and Tellis (1997), the time-to-sales takeoff is obtained by finding the year when the probability of no takeoff (i.e., survival probability) falls below 50% (Allison, 1995). For example, to determine the effects of an increase in innovative activity: (1) the *New Firm Entry* equation in Table 4 is used to calculate the direct effects of an

Table 5. Estimation Results for the Proportional Hazard Model of Sales Takeoff[a]

	Model 1	Model 2	Model 3	Model 4
ΔPrice	– 1.16 (2.82)	– 5.43 (7.54)	– 6.08 (7.54)	– 6.70 (7.59)
New Firm Entry	15.95* (3.31)	16.00* (3.39)	15.61* (3.46)	15.56* (3.51)
Year	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)
R&D Costs		0.04 (0.15)	0.03 (0.14)	0.03 (0.14)
R&D Costs × *ΔPrice*		0.61 (0.81)	0.76 (0.86)	0.93 (0.91)
Market Penetration			– 0.33 (0.61)	– 2.28 (2.13)
Market Penetration^2				1.46 (1.52)
ρ^2	0.38	0.38	0.39	0.39
– 2log likelihood (chi-square)	80.00 (48.85*)	79.35 (49.51*)	79.05 (49.82*)	78.12 (50.75*)

[a] Standard errors in parentheses.
* Significant at .01 level.

increase in *Patent Stock* on *New Firm Entry*; (2) the *ΔPrice* equation in Table 4, along with the newly updated *New Firm Entry* value, is used to calculate the indirect effects of this increase in *Patent Stock* on *ΔPrice*; and (3) the newly updated *New Firm Entry* and *ΔPrice* values in the sales takeoff equation in Table 5 are used to calculate the direct and indirect effects of this increase in *Patent Stock* on sales takeoff times. The results of this analysis for *Patent Stock*, *Large Firms*, and *R&D Costs* are in Figure 3. Overall, it is clear that an increase in the proportion of large firms in a new market has the biggest impact on reducing sales takeoff times, followed by the growth in patent stock and R&D costs.

The direct and indirect effects of *ΔPrice* and *New Firm Entry* on sales takeoff times can also be considered. To determine the indirect effects of decreases in *ΔPrice* on sales takeoff times, the following steps are used: (1) the *New Firm Entry* equation in Table 4 to calculate the effects of a decrease in *ΔPrice* on *New Firm Entry*; and (2) the *ΔPrice* and updated *New Firm Entry* values in the sales takeoff equation in Table 5. For the direct or exogenous effects associated with decreases in *ΔPrice*, the original values of *ΔPrice* and *New Firm Entry* in the sales takeoff equation in Table 5 were used. As indicated in Figure 4A, the effects of decreases in price on sales takeoff times are considerably different depending on whether the indirect effects are considered. If prices are incorrectly assumed to be exogenous, the results suggest that decreases in price are associated with quicker sales takeoffs. However, analyses of the indirect price effects show that decreases in price are actually related to longer sales takeoff times. The results in Tables 4 and 5 provide an explanation: Though falling prices may generate additional sales—and are marginally associated with faster sales takeoffs—the implied reduction in potential profits is associated with lower firm entry, which in turn is related to longer sales takeoff times. An analogous analysis of direct and indirect effects associated with *New Firm Entry* reveals that increases in firm entry are generally associated with shorter sales takeoff times (Figure 4B).

Conclusions

A primary motive for the present study is to increase the substantive understanding of firm entry and pricing behavior in new markets before sales takeoff. This study focuses on explaining the observed wide variation in firm activities during the introductory period of new markets when sales are minimal. To do

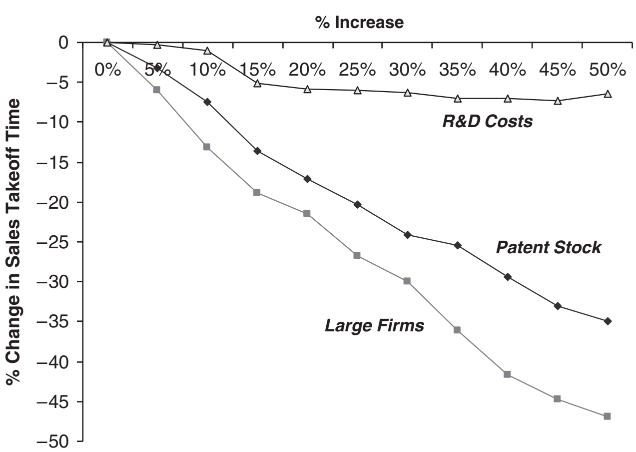

Figure 3. Sensitivity Analysis of Exogenous Factors on Sales Takeoff Time

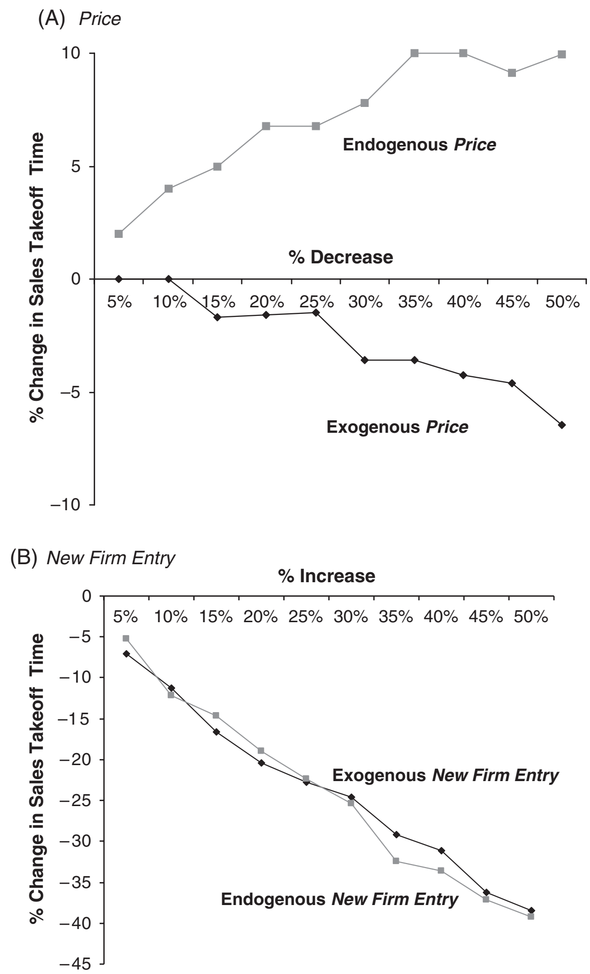

Figure 4. Sensitivity Analysis of Endogenous Factors on Sales Takeoff Time

this, a simultaneous system of equations in which new firm entry and price are endogenous factors is developed. The empirical analysis in this article provides strong support for this simultaneous viewpoint. Indeed, firm entry is found to be positively related to price decreases, and, at the same time, price decreases are negatively related to new firm entry. This particular relationship between price and firm entry (i.e., a negative feedback loop) indicates that the attractiveness of a new industry eventually diminishes as more and more firms enter.

Contributions

A summary of this study and its contributions over the existing literature is shown in Table 2. Though the key causal factors—price declines and new firm entry—related to sales takeoff have been identified in prior work, extant literature has treated these factors as being largely exogenous and independent of each other. By doing so, prior studies have failed to examine in detail the underlying factors that create growth in new markets and the determinants of price declines and new firm entry. This study develops hypotheses that examine the causes of price declines and new firm entry and, in particular, the potential feedback effects the two variables have on each other. By doing so, several new findings and insights are obtained.

First, based on results for the *New Firm Entry* equation in Table 4, firm entry during the introductory period is driven by expected profits, which is mainly signaled by the patenting activity in the new market. High levels of innovative opportunities mean that the inherent market and technical uncertainty usually associated with new markets will be resolved relatively quickly and that a new entrant can successfully compete by developing its own differentiated product offering. Importantly, this explanation for new firm entry into new markets when sales are negligible does not depend on current or lagged profitability or industry growth rates. Thus, Agarwal and Bayus (2002) is extended by showing that though new firm entry may be deterred by falling prices, high levels of innovative activity spur firms to enter the new market.

Second, based on the results for the *ΔPrice* equation in Table 4, price declines in a new market are primarily driven by the competitive pressure associated with firm entry. These results help provide insights into the underlying causal framework for the findings by Golder and Tellis (1997): Price declines are not the result of strategic monopoly pricing behavior undertaken by a single or few firms prior to sales takeoff but instead occur due to supply-side effects associated with new firm entry. As already noted, the number of competing firms in a new market is generally low immediately after commercialization; competition then rapidly increases so that a takeoff in the number of firms occurs before the end of the introductory period (see Figure 1). Increases in the supply-side capacity associated with firm entry causes an outward shift in the supply curve, which subsequently puts downward pressure on prices. Notably, this explanation for falling prices does not depend on cumulative sales or experience effects.

Third, the theoretical framework developed for the period before sales takeoff in a new market (Figure 2) is distinct from extant models that explain price declines or firm entry in the growth or mature stages of a market. Existing models for price declines in the later stages identify key drivers being either shifts from product innovation to process innovation as a market matures (e.g., Klepper, 1996; Utterback, 1994) or from production experience and learning curves (e.g., due to cumulative sales). Neither factor is applicable in the period prior to sales takeoff. Indeed, an important contribution of this article is to identify the role of competitive pressure due to firm entry in causing price declines before sales takeoff. As mentioned earlier, this finding contrasts with the implicit assumption by Golder and Tellis (1997) that strategic monopoly pricing behavior is related to price declines. Similarly, though firm entry may be broadly related to expected profits regardless of whether the market is in the presales takeoff, growth, or mature stage, the measures of potential profit will clearly differ by stage in the product life cycle. Though conventional measures like lagged profits can readily be used after sales take off, measures of potential profit that can plausibly be used in the period before sales take off are identified.

Finally, there are important implications for firm strategy. As opposed to the recommendation by Golder and Tellis (1997) that firms should strive to reduce the prices they charge in new markets—a strategy most likely based on an assumption of strategic monopoly pricing behavior—the present study shows that any conclusions regarding the effects of price on the timing of a sales takeoff crucially depend on whether the indirect effects of price and new firm entry are considered. In contrast to Agarwal and Bayus (2002), rapidly declining prices in a new market are found to be associated with longer takeoff times when the indirect effects of price are considered. Unlike the analysis and recommendations of Foster, Golder, and Tellis (2004), price is not the only significant driver of a sales takeoff. In particular, a managerial strategy of decreasing prices in an emerging market may have some unintended consequences; that is, the sales takeoff may be delayed even further.

Limitations and Future Research Directions

As with all empirical research, generalizations of the conclusions beyond the data and measures analyzed should be done with care. At the same time, any study limitations offer opportunities for future research. Clearly, the theoretical framework needs to be tested in other industry settings as well as in international markets. An important direction for future research is to further refine the new firm entry and patent stock measures used in this study so that the supply-side effects (i.e., capacity increases and process improvements) are cleanly separated from the demand-side effects (i.e., product improvements). Several alternative measures of innovative opportunity might be considered—for example, citation adjusted patents, R&D expenditures, new product announcements (see Hagedoorn and Cloodt, 2003). In addition, greater details of the activities of large and small firms, as well as the innovation strategies they employ (e.g., provisional patent applications, licensing, patent renewals) during the introductory period, may lead to further insights into the creation of new markets. Further information on firm characteristics, resources, and capabilities could also be helpful in gaining deeper insights into firm actions that lead to success in new markets.

Though this study highlights the typical pattern of industry evolution in Figure 1, the deviations of a few specific markets suggests that detailed industry case studies can also increase understanding. For example, the fact that the turbojet engine had increasing prices, increasing competition, and a relatively quick sales takeoff suggests that measures of product quality need to be refined and added in the analysis. In addition, a detailed study of the role of firm exit is beyond the scope of this study. An investigation of firm behavior related to early exit from emerging markets represents an important avenue for future research. In particular, longer sales takeoff times and sustained levels of higher prices can be associated with markets in which the early entrants prematurely abandon their innovation and product improvement efforts.

Finally, the findings in this article suggest that firm entry, together with the collective innovative activity of competing firms, is crucial to the creation of growth in new markets. A strategy by which a firm wants to encourage other firms to enter a new industry is entirely consistent with a real-options viewpoint (e.g., Amram and Kulatilaka, 1998). By initially entering a new industry in a limited fashion, a firm takes an option to grow at a later time. Only after the market and technical uncertainty associated with the new innovation is resolved will the firm possibly exercise this option by significantly committing resources. In this case, the combined innovative activity of several competing firms reduces this uncertainty faster than the efforts of a single firm, leading to an explosion in firm entry and sales. Future empirical and analytical research might explicitly consider such a perspective to further explain how new markets are created.

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