Deconstructing the Pioneer’s Advantage: An Examination of the Relative Success and Failure of Market Pioneers

Jonathan D Bohlmann
Eli Broad Graduate School of Management
Michigan State University
370 North Business Complex
East Lansing, MI 48824

and

Peter N. Golder
Stern School of Business
New York University
44 West 4th Street, KMC 8-79
New York, NY 10012

and

Debanjan Mitra
Warrington College of Business Administration
University of Florida
Gainesville, FL 32611

The authors thank seminar participants at Purdue and MIT for helpful discussions. Bill Robinson, Eric Anderson, Sudhir Karunakaran and Yuxin Chen also provided valuable comments. The encouragement and suggestions of Birger Wernerfelt are especially appreciated. The usual disclaimer applies.
Deconstructing the Pioneer’s Advantage: An Examination of the Relative Success and Failure of Market Pioneers

Abstract

Several studies have demonstrated an order of entry effect on market share, suggesting that pioneers outperform later entrants. However, other research has pointed out the limitations of these studies and found evidence that many pioneers actually fail or have low market share. Given this background, the purpose of this research is to understand the conditions under which pioneers are more likely and also less likely to have an advantage. According to Lieberman and Montgomery (1998), understanding the impact of different environmental conditions on the strategic choices of pioneers and followers is one of the most important areas for future research on the issue. Therefore, we propose a game-theoretic model that includes important sources of pioneer advantages as well as disadvantages. Specifically, we incorporate a pioneer advantage due to preemption in markets with heterogeneous tastes. In addition, we incorporate a potential pioneer disadvantage due to technology vintage effects where later entrants utilizing improved technology can have lower costs and higher quality. The model allows us to evaluate the extent of vintage effects necessary to overcome a pioneer's advantage. Key relationships are found between the magnitude of the pioneer advantage or disadvantage and consumers' valuation of product attributes (e.g., variety and quality). We present three case studies that illustrate key elements of the model. We empirically validate the model with vintage effect data in 36 product categories, and brand-level longitudinal data for 12 of these 36 categories. The results show that pioneers do better in product categories where variety is more important, while they do worse in categories where product quality is more important. Pioneers in categories with high vintage effects are shown to have lower market shares and higher failure rates. Similar results appear
when analyzing persistence of market leadership over time, further validating our model’s major implications.

KEYWORDS: pioneering, order of entry
Introduction

The strategy of pioneering new markets is widely considered to be a cause of long-term success. Several studies have demonstrated an order of entry effect on market share, indicating that pioneers tend to outperform later entrants (overviews are found in Kalyanaram et al. 1995; Lieberman and Montgomery 1988, 1998). However, some research has pointed out the limitations of these studies and found evidence that many pioneers actually fail or have low market shares (Golder and Tellis 1993; Schnaars 1994). Even those studies that support an order of entry effect find that the magnitude of this effect varies across product categories. For example, pioneers of consumer goods have higher market shares than pioneers of industrial goods on average (Parry and Bass 1990; Robinson 1988; Robinson and Fornell 1985). Also, some studies show that pioneering advantages diminish over time (Brown and Lattin 1994; Kalyanaram et al. 1995; Shankar et al. 1998).

Since current research demonstrates that pioneers’ market shares vary widely, the objective of this research is to explain some of the conditions under which pioneers are more likely and less likely to have a market share advantage. To the best of our knowledge, current research has not addressed this important issue in an integrative fashion considering advantages and disadvantages both theoretically and empirically. According to Lieberman and Montgomery (1998), understanding the impact of different environmental conditions on the performance of pioneers and followers is one of the most important areas for future research. At present, theoretical research focuses on potential sources of pioneer advantage, but does not propose an explanation for why many pioneers are overtaken by later entrants. We offer such an explanation in this paper.

To accomplish our objective, we propose a game-theoretic model that includes important sources of pioneer advantage as well as sources of disadvantage. Specifically, we incorporate a
pioneer advantage due to preemption in markets with heterogeneous tastes. This mechanism has been widely cited as a common advantage of pioneers (Kerin, Varadarajan and Peterson 1992; Lieberman and Montgomery 1988). In addition, we incorporate a potential pioneer disadvantage from technology vintage effects where later entrants utilizing improved technology can have lower costs and higher quality. Even though improved technologies are available to pioneers and followers, firms that have already made cost and managerial commitments to one technology are less likely to be early adopters of an advance in technology (Henderson 1993; Lieberman and Montgomery 1988). Several examples illustrate this phenomenon. Sony persisted with the Beta VCR in the face of overwhelming evidence that consumers preferred the longer playing time of VHS VCRs. IBM moved slowly into workstations even though new firms such as Sun were enjoying tremendous success. Douglas Aircraft lost its dominance of the U.S. aircraft industry to Boeing as planes switched from propellers to jet engines.

Our model allows us to demonstrate several important results. First, we show that vintage effects can be an important source of advantage for later entrants. Second, we evaluate the extent of vintage effects necessary to overcome a pioneer's advantage at varying levels of market preemption. Third, we demonstrate key relationships between the magnitude of the pioneer’s advantage or disadvantage and consumers' valuation of product attributes (e.g., variety and quality). Model extensions are briefly considered to relate our model to other general sources of pioneering (dis)advantage and the optimal entry timing decision by a later entrant.

We present three case studies to illustrate the key elements of the model. We empirically validate the model with vintage effect data in 36 product categories, and brand-level longitudinal data for 12 of these 36 categories. The results are consistent with our model, showing that pioneers do better in product categories where variety is more important, while they do worse in categories where product quality is more important. Pioneers in categories with high vintage
effects are also shown to have lower market shares and higher failure rates. We obtain similar results when analyzing persistence of market leadership over time, further validating our model’s major implications.

In the next section, we present a brief introduction to vintage effects and review models that demonstrate a pioneer advantage. Then, we develop our model. It includes a pioneer advantage from preemption effects and a pioneer disadvantage from vintage effects. Following that, we discuss several model extensions, present the case studies, and empirically validate our model. We conclude with a summary of our key findings and discuss their implications for managers and researchers.

**Overview of Product Entry Models and Pioneer Advantage**

Theoretical models of product entry usually distinguish between horizontal differentiation and vertical differentiation. Horizontal differentiation is most often based on Hotelling’s “linear city” concept, where consumers typically have different product ideal points modeled along a line (see d’Aspremont, Gabszewicz, and Thisse 1979; Hotelling 1929). Consumers suffer increasing disutility as the distance between the consumer’s ideal point and the product location increases. Vertical differentiation, in contrast, is characterized by consumers agreeing that “more is better” for the product attribute, although there may be heterogeneity in valuations for the attribute. The horizontal product dimension is usually labeled “variety,” while the vertical dimension is thought of as “quality.” An example of both dimensions is a consumer’s general desire that computer software runs quickly and allows commands to be entered easily. Processing speed is a vertical attribute (nearly everyone agrees that faster is better), while “easy to use” is a horizontal attribute (some prefer keystroke commands, others prefer various menu systems, while still others prefer some combination of both).
When firms compete on price, they tend to offer differentiated products to avoid severe price competition (examples of differentiated product models include Economides 1989; Hauser 1988; Hauser and Shugan 1983; Neven and Thisse 1990; Shaked and Sutton 1982; Vandenbosch and Weinberg 1995). With sequential entry, the threat of price competition enables the pioneer to enter at the optimal location while later entrants differentiate themselves at less optimal locations. Thus, under these conditions, pioneers enjoy higher market shares. Such preemptive pioneer advantage has been typically modeled as arising from heterogeneity in consumers’ ideal points or valuations of product attributes (e.g., Ansari, Economides and Ghosh 1994; Lane 1980; Moorthy 1988; Prescott and Visscher 1977). In general the pioneer has market share and profit advantages due to successful preemption of the most favorable market space.

Besides locating in the optimal product position, several other processes may also lead to a pioneer advantage. First, when consumers learn about new products, their ideal points may be influenced toward the pioneer’s attributes (Carpenter and Nakamoto 1989). Since consumer preferences may be weakly formed, at least initially, a pioneer may become the category standard for consumers. Second, consumers who have successfully used the pioneer’s product are reluctant to try a later entrant’s product because its quality is uncertain (Muthukrishnan 1995; Schmalensee 1982). Third, a pioneer may be more salient in consumers’ memories due to sequential information processing of products, resulting in more favorable judgments about the pioneer and more frequent consideration for purchase (Kardes and Kalyanaram 1992). Finally, pioneers may be able to generate brand loyalty by inducing trial early and establishing switching costs (Gabszewicz, Pepall, and Thisse 1992). All these mechanisms of preemptive advantage may allow pioneers to secure higher market share than later entrants.

In spite of the processes by which pioneers might have a preemptive advantage, a pioneer may face disadvantages by being first, especially when technology improves over time.
(Lieberman and Montgomery 1988). As technology advances, later entrants can utilize a more recent and efficient vintage of technology than an earlier entrant who has committed to older technology. Primarily studied as a source of productivity improvements, vintage effects can result in lower costs for later entrants (Intriligator 1992; Johansen 1959, 1972). These technology cost advantages could lead to higher quality products and/or lower prices, as evidenced by the personal computer becoming faster and cheaper over time. Models and empirical observations of incumbent inertia suggest that vintage effects will benefit later entrants, since incumbent pioneers will tend to underinvest in improving technologies (Ghemawat 1991; Henderson 1993; Henderson and Clark 1990; Reinganum 1983), although there are exceptions (Christensen and Bower 1996; Christensen and Rosenbloom 1995).

Cost advantages can also relate to productivity improvements through experience effects. In the case of learning by doing, costs will tend to decline with more production experience (see, for example, Arrow 1962; Bahk and Gort 1993; Spence 1981). Although affecting all firms, learning by doing would likely favor earlier entrants that have been producing longer, at least in the near term (Fershtman, Mahajan and Muller 1990). Depending on the effects of technology vintage, however, a later entrant could still have lower costs than the pioneer even without the full advantage of learning by doing. Whether through learning by doing or utilizing better production technology, the result is different costs for the pioneer and a later entrant. Although we posit empirically that vintage effects will on average tend to benefit later entrants, our model is sufficiently general to examine situations that might benefit the pioneer, such as experience curve effects or innovation capabilities that benefit existing customer value networks (e.g., Christensen and Rosenbloom 1995).

In the next section we present a sequential entry variety-quality model. We consider a pioneer’s preemption advantage in product variety and a potential disadvantage in the cost of
producing quality between the pioneer and later entrant. Afterwards, we briefly present model extensions that demonstrate various mechanisms of pioneer (dis)advantages and their effects on entry timing. Finally, we present an empirical validation of the model’s results, and implications for pioneering strategies.

Variety-Quality Product Entry Model

The assumptions and basic structure of the model are similar to other product differentiation models considering simultaneous and/or sequential product entry (e.g., Economides 1989; Moorthy 1988; Neven and Thisse 1990; Shaked and Sutton 1982; Tyagi 2000; Vandenbosch and Weinberg 1995). In contrast to earlier models, our model simultaneously considers sequential entry, differences in costs-of-quality between firms, and both variety and quality product dimensions. More specifically, we model a pioneer advantage through preemption by considering a market with heterogeneous tastes in product variety. In addition, we incorporate vintage effects by allowing the pioneer and later entrant to have different production costs in the product quality dimension, where lower costs can lead to higher quality (Moore, Boulding and Goodstein 1991; Parry and Bass 1990). Through higher product quality, a vintage effect results in later entrants being able to reduce the preemptive pioneer advantage, or even in later entrants actually becoming the market leader. By including cost-of-quality differences our model can also incorporate an increased pioneer advantage due to experience curve effects, or other competencies that would mitigate a later entrant’s potential quality advantage. Our model has some similarities to Tyagi (2000), who focused on production cost differences in a variety-only model (quality is ignored). Our model’s theoretical contributions lie in considering both variety and quality product dimensions under differing costs-of-quality between firms, and the incorporation of consumer valuations for variety and quality.

To begin the variety-quality model construction, assume there are only two firms that serve the market. We specify one firm as the pioneer who enters the market first (Firm 1), while
the other firm is the later entrant (Firm 2). Each firm offers a product with own quality level $q_i$ and variety level $y_i$ at price $p_i$, $i = 1, 2$. We assume a market where different consumers prefer different levels of product variety. Consumers’ ideal points $\theta$ are uniformly distributed on the interval $[0,1]$ with unit density. Consumers experience a loss of utility when purchasing a product with variety different from their ideal, scaled by parameter $a$. All consumers have an identical valuation $b$ for product quality. A consumer whose ideal variety level is $\theta$ and buys a single unit at price $p$ has utility of:

$$U(\theta) = U_0 - a|\theta - y| + bq - p \quad a > 0, b \geq 0$$

The parameter $U_0$ is the inherent value of the good, which is taken large enough such that all consumers purchase a single unit of the product.

We assume both firms will enter or remain in the market if they can receive non-zero profits. Firms have identical costs to producing variety, set to zero without loss of generality. Firms incur variable costs related to product quality of $c_i q_i^2$, $i = 1, 2$, where $c_i$ is firm $i$’s cost-of-quality. We assume that the pioneer cannot copy an improved production technology utilized by a later entrant, consistent with other models of vintage effects (Intriligator 1992; McLean and Riordan 1989) and widespread observations of incumbent inertia (e.g., Ghemawat 1991; Henderson 1993; Henderson and Clark 1990; Reinganum 1983). We utilize a three-stage sequential entry game. In stage 1 the pioneer sets quality and variety levels $(q_1,y_1)$, in stage 2 the later entrant sets quality and variety $(q_2,y_2)$, and each firm simultaneously sets prices in stage 3. We assume without loss of generality that $y_2 \geq y_1$. We also assume that the pioneer allows and foresees entry by the second firm. Since our focus is on the potential ability of a later entrant to overtake a pioneer, and not on the number of firms or products competing in the market, we do not explicitly model a pioneer’s period of monopoly profits, nor include fixed costs or product line extensions as entry deterrence mechanisms.

To focus on the model results and intuition, details of the variety-quality model equilibrium are presented in Proposition A1 in the Appendix. The competitive equilibrium is
such that the pioneer gains a preemptive advantage by optimal selection of product variety in a heterogeneous market. The equilibrium results can be summarized through a quality differential parameter $Q$, expressed as $Q = b(q_i^* - q_e^*)^2$, where a firm’s optimal product quality is solely a function of the firm’s own costs, specifically $q_i^* = b/2c_i$. The $Q$ parameter captures the equilibrium quality difference between the firms, scaled by the consumers’ relative importance of quality to variety ($b/a$). Note that $Q$ is positive (negative) if the pioneer (later entrant) has a quality advantage due to lower cost-of-quality.

The model results show that vintage effects, through differences in product quality, impact the pioneer advantage or disadvantage. Figure 1 plots the pioneer and later entrant’s equilibrium market shares as a function of $Q$. If the pioneer has a lower cost-of-quality than the later entrant ($Q > 0$), such as due to experience curve effects, the pioneer’s quality advantage will increase the pioneer’s market share advantage. However, if the later entrant is able to produce higher quality than the pioneer ($Q < 0$), the pioneer’s preemptive advantage will be reduced due to the vintage effect. If the later entrant has a sufficient quality advantage such that $Q < -0.25$, the later entrant will be the market-share leader. Note that the pioneer advantage due to preemption means that the pioneer can produce inferior quality, but still have higher market share (and profits) than the later entrant, when $-0.25 < Q < 0$. The pioneer’s profit (dis)advantages as a function of $Q$ are similar to the market share patterns. The model thus formalizes our intuition of vintage effects for later entrant advantage.

---

Insert Figure 1 about here

---

The more interesting contribution of our model arises from studying how the pioneer’s advantage or disadvantage also depends upon the consumers’ valuations for variety, $a$, and quality, $b$. In particular, if consumers have a higher valuation for variety, a firm’s cost-of-quality
advantage will be less important such that vintage effects might have relatively little impact on a later entrant’s success. This situation is more common with non-durables such as food where personal tastes are more important. On the other hand, when consumers have a high valuation for quality, even a small cost advantage can become a significant boost to market share and profits. This situation might be more common with durable goods where there tend to be objective measures of quality and performance. From the variety-quality model equilibrium solution, we use comparative statics results to establish these results formally:

PROPOSITION 1a: If the pioneer has a cost-of-quality advantage ($Q > 0$), the pioneer’s (later entrant’s) market share and profits increase (decrease) as the consumers’ valuation of quality, $b$, increases. The opposite effect holds if the later entrant has a cost advantage ($Q < 0$).

PROPOSITION 1b: If the pioneer has a cost-of-quality advantage ($Q > 0$), the pioneer’s (later entrant’s) market share decreases (increases) as the consumers’ valuation of variety, $a$, increases. The opposite effect holds if the later entrant has a cost advantage ($Q < 0$). Profits for both firms increase as $a$ increases.

The comparative statics results highlight how a pioneer advantage can be effectively enhanced or eroded depending on consumer valuations for quality and variety. For example, the adverse impact of a quality disadvantage (due to higher costs) on market share is less pronounced as consumers value variety more highly. Therefore, a pioneering firm may find advantage in a strategy where it enters markets with high preemptive advantage and relatively weak potential for higher-quality later entrants to overtake its advantage (see Pepall 1992 for a similar result). This occurs in situations where consumers place high valuation on variety. Conversely, as consumers value quality more, a later entrant can effectively reduce a pioneer advantage through a higher-quality product. The effect can be dramatic, as it was in Japan’s disposable diaper market where consumers place high value on product quality. Later entrants with superior quality eroded the pioneer’s market share from 90% to under 10% in just a few years (Business Week 1986). A similar result occurred in the anti-ulcer ethical drug market, where a high-quality second entrant overtook the pioneer that lagged in product improvements.
(Berndt et al., 1995). Given that a later entrant’s quality advantage will have little effect when variety dominates, later entrants might use advertising or other marketing activities to persuade customers of the importance of higher quality (e.g., Shankar 1999).

The important contribution of consumer valuations for pioneering success or failure holds implications even when it is not clear that vintage effects will benefit the later entrant. For example, experience curve effects reducing cost-of-quality will tend to accrue more rapidly to the pioneer, but this will not translate into market share rewards if consumers have high valuation of variety over quality. The work of Christensen and colleagues (1995, 1996, 1997) indicates that incumbents can be better at innovation within established customer valuation and technological trends, but later entrants are better at disruptive innovations. In the context of our model, pioneers will certainly benefit from a quality advantage when valued highly by current customers (Proposition 1a), giving incentives to pioneer’s to implement particular quality improvements. However, under an emerging shift in the product quality attributes valued most by the market, customers may tend to de-emphasize the quality dimensions favored by the pioneer and value more the qualities represented in the later entrant’s “disruptive” product innovation. If so, our model suggests that the later entrant will succeed more quickly as consumers increase more rapidly the valuations they place on its product’s quality features.

To further appreciate how quality advantage impacts market shares given our model’s parameters, consider first the size of the pioneer’s preemptive advantage. When quality is equal \(Q = 0\), the pioneer’s market share is 55%. The later entrant can eliminate the pioneer’s advantage and achieve an equal market share at \(Q = -0.25\). If the pioneer could achieve a quality advantage of the same magnitude (perhaps by experience curve effects), or \(Q = 0.25\), the pioneer’s market share dominance would increase to slightly over 60%. How much vintage effect would be needed for the later entrant to achieve the same level of market dominance? For a 60% later entrant market share, we would need \(Q = -0.76\), or nearly three times the quality advantage it would need to erase the pioneer’s preemptive advantage. More generally, for a given market share or profit reward, the later entrant must achieve a substantially greater quality
advantage than the pioneer would need for the same market share or profit. Our model therefore offers a strategic explanation of why pioneer’s might be more incremental in their technology improvements than later entrants. Due to preemptive advantage, a pioneer can reach a given strategic market share or profit objective with substantially less quality improvements, compared to a later entrant hoping to achieve similar market share or profit objectives.

The consumer valuations essentially act as leverage as the firms attempt to capitalize on strengths or defend against competitive attacks. For example, taking the 60% market share from above as a base case for each firm, a 50% increase in the consumer valuation of quality (holding costs-of-quality and variety valuation constant) will increase the pioneer’s market share from 60% to 67%, leveraging the quality advantage consistent with Proposition 1a. Under a later entrant’s quality advantage, the same 50% increase in quality valuation will grow its market share from 60% to 78% (recall that the later entrant needed a substantially higher quality advantage to reach 60% market share in the first place). Considering a change in variety valuations, holding all else constant, doubling the variety valuation will take the later entrant’s market share from 60% to 53%, while halving the variety valuation improves market share from 60% to 74%. Consistent with Proposition 1b, higher variety valuation does not allow the later entrant to leverage its quality advantage in terms of market share. Lower variety valuations, however, diminish the pioneer’s preemptive advantage, enabling the superior quality later entrant to more easily take market share away from the pioneer. Variety valuations thus act as the pioneer’s defensive basis against a later entrant’s quality attacks, while also generating profits due to preemptive advantage.

In summary our model demonstrates how vintage effects can give advantages to a later entrant (due to lower costs and higher product quality) which can reduce or eliminate a first-mover advantage due to preemption, or even drive the pioneer out of the market completely. Importantly, the degree to which a later entrant’s vintage effect or a pioneer’s experience curve
effects can reduce or enhance the pioneer advantage is dependent upon how consumers value product quality and variety.

**Model Extensions**

Our model has made standard assumptions about perfect foresight and information. Obviously, if the pioneer fails to capitalize on a preemptive advantage, then advantages we have ascribed to the pioneer may instead accrue to the more fortunate later entrant. The intuition of the model remains intact, although it is formulated for situations where the pioneer disadvantages are not the result of bad luck or ignorance. We also recognize that there are other potential sources of quality differences aside from the model’s cost-of-quality, and a pioneer’s preemptive advantage may not be limited to product variety. Our model is general enough, however, to accommodate other sources of pioneering (dis)advantage (details of the following extensions are available from the authors).

For example, besides a first-mover advantage through preemption in product variety, the pioneer may also enjoy an advantage over a later entrant due to some “subjective” advantage, i.e., consumers may simply prefer the pioneer because it is the pioneer. We think here of a general subjective preference for the pioneer’s product, which might be attributed to consumer learning advantages for the pioneer’s product (Carpenter and Nakamoto 1989; Kardes and Kalyanaram, 1992), decision ambiguity or product uncertainty that favors a better-known pioneer (Muthukrishnan 1995; Schmalensee 1982), or the pioneer being considered more often by consumers (Kardes et al., 1993). The result of including a subjective pioneer advantage into the model is straightforward. Instead of the equilibrium dependent on quality differences as determined by cost-of-quality, it is additionally dependent on the size of the pioneer’s subjective advantage, incorporated into the model with a simple transformation of the parameter $Q$. Just as
the base model relates optimal strategies to the consumer valuations, the model extensions can include valuations for other sources of (dis)advantage. For example, advantages related to quality uncertainty (e.g., Schmalensee 1982) would be leveraged according to quality valuations and/or risk aversion. Our model can thus be easily extended beyond the modeled product variety and quality.

Our model’s important results related to consumer valuations also have strategic implications for entry timing by the later entrant. For both consumer and industrial goods, a general finding is that a pioneer’s share advantage due to higher quality decreases over time (Robinson 1988; Robinson and Fornell 1985). This could be due to production quality diffusion, or vintage effects and “incumbent inertia” resulting in more efficient costs for later entrants. An important dynamic consideration is when the later entrant should enter. One might suspect, consistent with some empirical evidence, that the pioneer advantage would become stronger as later entry is delayed (Huff and Robinson 1994). This could be related to experience curve effects or to a pioneer’s various subjective advantages, as described earlier, becoming stronger over time. However, the vintage effect can motivate a later entrant to delay entry if sufficient technology improvements can substantially improve quality. A recent study by Narasimhan and Zhang (2000) indicates that a later entrant will delay entry if it can gain sufficient advantage, but consumer valuations and the speed at which advantages accrue are not considered. We can extend our variety-quality model to address these issues.

Consider that the pioneer enters at time zero. Further assume that in addition to variety preemption, the pioneer has a subjective quality advantage (initially zero) that increases over time until the later entrant enters, whereafter it stays constant. The later entrant may, by delaying entry, reduce the cost-of-quality due to improving technology. Once entry occurs production costs are locked in. We can think of cost reductions due to vintage effects being net
of experience curve effects, such that we assume for simplification that the pioneer’s costs do not change. For tractability, assume that the change in the subjective quality advantage is linear over time. Also assume that production technology improves over time such that costs decrease in a way where parameter $Q$, capturing the difference in the firms’ produced quality, decreases linearly over time.\(^3\) To determine when entry occurs, the later entrant maximizes its discounted profits with respect to its entry time $T$. With our assumptions we can express the later entrant’s discounted profits with respect to the value of $Q$ at entry time $T$, and utilize the implicit function theorem to derive the following comparative static results (proof available upon request):

**PROPOSITION 2.** Assuming that an interior solution exists, the later entrant will enter sooner for a lower consumer valuation of product quality ($b$), higher consumer valuation of variety ($a$), lower rate of decrease of cost-of-quality, higher rate of increase in the pioneer’s subjective quality advantage, and higher discount rate.

Although this is a fairly simple example of an entry-timing decision, it does illustrate that consumer valuations of variety and quality product attributes impact the entry timing strategy, in addition to the rate at which costs and subjective quality perceptions change. In particular, note that vintage effects can motivate the later entrant to be more patient when consumers have high value of product quality and/or the cost-of-quality advantage accrues more rapidly. This holds even if the later entrant could enter immediately with a quality or even a market share advantage. The gains to waiting in order to introduce an even higher-quality product offset any profit gains from fast entry. At the same time, high variety valuation will cause the later entrant to enter earlier with a lower quality product, allowing the pioneer to leverage its preemptive advantage. The results reveal important speed-to-market and product quality tradeoffs that are critically dependent upon consumer valuations.

We next present empirical evidence that supports our model’s basic implications.
Empirical Validation of Model

We validate our model in two ways. First, we present three case studies that illustrate key elements of the model. Second, we use multiple product categories to estimate three key model variables: vintage effects, consumer valuation of quality, and consumer valuation of variety. We then evaluate the impact of these variables on pioneers’ market share and the long-term stability of market leadership.

Case 1: Commercial Aircraft Market

One of the key elements of our model is that vintage effects relating to new technologies enable later entrants to provide lower costs and higher quality. A key assumption in our results is that later entrants are more likely to take advantage of these new technologies. Christensen (1997) has written extensively about the inability of leading incumbents to successfully adopt disruptive, new technologies. Other researchers have also documented this phenomenon (e.g., Ghemawat 1991; Henderson 1993; Henderson and Clark 1990; Reinganum 1983). We now describe a case to support our assumption that later entrants benefit from vintage effects.

Douglas Aircraft Company dominated the commercial aircraft industry from the late 1930s until the mid-1950s with the DC-3 and its derivatives. These propeller-driven aircraft comprised over 95% of the U.S. commercial aircraft fleet in 1946. The first commercial jet-engine aircraft was the British De Havilland Comet, introduced in 1949. This pioneering effort became a business and human tragedy after several early Comets crashed killing all passengers.

In the early 1950s, Boeing sold many military aircraft, but no commercial aircraft. Thus, Boeing trailed not only Douglas, but also Lockheed and Convair in commercial aircraft sales. However, by 1953, Boeing was well ahead of its rivals in developing a commercial jet-engine aircraft. In 1954, Boeing’s 707 prototype flew for the first time and the following year American Airlines ordered 30 of these jets. This order finally pushed Douglas into developing its own
commercial jet. However, in order to act quickly, they produced the DC-8 without the benefit of a prototype and they did not build enough manufacturing capacity to satisfy demand. Meanwhile, Boeing secured several pre-production orders and was prepared to meet demand. Even though Douglas delivered its jet aircraft only one year later than Boeing, the success of the two companies was permanently reversed. Between 1954 and 1958, Douglas’ market share of commercial aircraft averaged 54%. In 1959, the first full year of 707 sales, Boeing captured 30% of the market and by 1964, Boeing’s market share was an incredible 92%.

Jet-engine aircraft delivered two key benefits to consumers. They could travel much faster than propeller-driven aircraft (550 mph vs. 300 mph) and they cost less to operate. In 1954, the cost per seat mile to operate a DC-3 was 2.32 cents (including depreciation). The newer propeller-driven DC-7 cost 2.07 cents to operate. In contrast, the first generation Boeing 707s cost only 1.77 cents to operate.

This case illustrates several important elements of our model. First, new technologies can be used to generate higher quality (i.e., more speed) and lower costs. Second, a company with limited involvement in the commercial aircraft market was the first to develop and market a jet-engine aircraft. This statement is true whether we consider the first company (De Havilland) or the first successful company (Boeing). Third, the adoption of the new technology led to a dramatic reversal in market leadership.

Case 2: Disposable Diaper Market

Another key result of the model is that pioneers perform poorly in markets where consumers have a high valuation on quality. Since 1961, Consumer Reports has evaluated disposable diapers on quality, suggesting that this attribute is most important to consumers. Also, the small number of brands in this category suggests that variety provides limited benefits to consumers. Although Consumer Reports considers many dimensions of quality (e.g.,
absorbency, strength, fit, etc.), the most important underlying aspect of quality for disposable diapers is the ability to prevent leaks.

The disposable diaper market was pioneered by Johnson & Johnson’s Chux brand in 1932. For several decades, Chux dominated this market with share as high as 75%. However, the size of the market remained small due to relatively poor quality and high prices. Even though P&G’s Pampers brand was not even mentioned in the 1961 *Consumer Reports* article, P&G had already begun a concerted effort in this market by then. While they designed sophisticated manufacturing machinery to produce high-quality, low-cost diapers, J&J continued to use the same machinery they had used since the 1930s. By 1967, *Consumer Reports* gave Pampers and Chux their highest quality rating. Importantly, Pampers sold for 5.4 cents each while Chux sold for 6.6 cents. According to an internal J&J report written in 1972, J&J was already beginning to realize in the 1960s that they could not compete against P&G’s superior product. By the early 1970s, J&J withdrew Chux from the market.

Since the early 1990s, Kimberly-Clark’s Huggies brand has been the top-selling disposable diaper. Kimberly-Clark’s initial entry in disposable diapers resulted in failure after the Kimbies brand developed a reputation for leaking. However, over many years, Kimberly-Clark continually beat P&G with many innovations to improve the quality of their diapers: adhesive tabs did away with the need for safety pins, fluff pulp replaced tissue paper and provided improved performance in absorbency and cost, elastic legs provided superior fit relative to Pamper’s folded design, and ultra-thin diapers were easier to store and wear under clothes. These quality innovations helped Huggies become the dominant brand of disposable diapers.

This market provides evidence of later entrants overtaking established leaders in markets where consumers have a high valuation of quality.
Case 3: Laundry Detergent Market

Another key result of the model is that pioneers tend to perform better in markets where consumers have a high valuation of variety. The laundry detergent market is such a market. In contrast with disposable diapers, many brands of laundry detergent are available. P&G alone sells six brands of powdered laundry detergent: Tide, Cheer, Bold, Dreft, Gain, and Ivory. In addition, Colgate and Lever Brothers sell All, Fab, Surf, and Wisk. The large number of brands suggests that consumers have heterogeneous tastes in their preference for laundry detergents, thus enabling a large variety of brands to succeed.

The U.S. laundry detergent market was pioneered by P&G in 1933 with the Dreft brand, a light-duty detergent. P&G introduced the first heavy-duty detergent in 1946. Tide heavy-duty detergent combined the surfactants of light-duty detergents with phosphate builders. Since heavy-duty detergents were significantly different from light-duty detergents, it is possible to consider them a separate category. However, whether we consider all detergents or just heavy-duty detergents, P&G and the Tide brand in particular have dominated the detergent market since inception. Their sustained leadership illustrates the long-term rewards that accrue to pioneers in markets where consumers have a high valuation of variety.

Ironically, P&G’s success in laundry detergents may have contributed to their loss of leadership in the disposable diaper market. In detergents, P&G succeeded by selling several brands since consumers had a high valuation on variety. In disposable diapers, P&G began to follow a similar strategy by introducing Luvs disposable diapers. By focusing on variety, and possibly less on quality, they lost market leadership to Kimberly-Clark, which focused all of its efforts on improving the quality of a single brand. The contrast between these two markets illustrates the insights from our theoretical model by showing the importance of understanding whether consumers value quality or variety.
Next, we describe our estimation of vintage effects, consumer valuation of quality, and consumer valuation of variety.

**Estimating Vintage Effects**

To measure vintage effects, we use the average annual price decline in a product category. Since competitive markets should cause declining costs to be reflected in declining prices, we believe that our measure is a reasonable operationalization of vintage effects (Day and Montgomery 1983; Lieberman 1987; Moore, Boulding and Goodstein 1991; Parry and Bass 1990; Robinson and Fornell 1985). Vintage effects also relate to improvements in product attributes, but we are unable to develop such comparable measures across categories over a long period. However, based on our analysis of many product categories, we believe that high annual price declines occur in categories where product attributes also tend to improve the most.

For our sample of products, we use the same 36 categories used in a previous study of market pioneers (Golder and Tellis 1993). Since this study does not consider prices, we conducted an extensive search for longitudinal price data for each of the 36 product categories. We collected a representative price for each product category as close to the year of the pioneer’s entry as possible. Then we found a current price for the most comparable item today. We used the same brand when price information was available at the brand level. For a few categories, establishing comparable items was a little more involved. For example, in laundry detergent, we used prices that were consistent for the same number of washes rather than the same number of ounces. All price data come from publicly available sources including *Electrical Merchandising, Consumer Reports, Business Week, Advertising Age*, and Electronics Industries Association reports. Older prices are standardized to 1999 dollars before annual percentage price declines are calculated. Current price data were collected in 1999. In Table 1 we present our data on price declines. In many categories, we have multiple data points. The overall
averages are calculated using the intra-category averages. We group categories by durables and non-durables to show that our measure of vintage effects is, intuitively, significantly higher for durables, where product attributes have also tended to improve more over time (average price decline of 5.4% for durables versus 0.5% for non-durables, a significant difference at p < 0.01).

Estimating Consumer Valuations of Quality and Variety

To evaluate the roles of quality and variety, we require data on multiple brands in multiple categories. After much effort, we were able to compile longitudinal brand-level data on market share, price, advertising, and quality for 12 of the 36 categories used to estimate vintage effects. We used four sources to compile our data set. Quality measures come from Total Research Corporation’s ‘Equitrends’ surveys. These surveys have been conducted at least once a year since 1989 and have been used in previous research (Aaker and Jacobson, 1994; Helloffs and Jacobson, 1999). Price data were collected from Consumer Reports from 1989 until the present. Advertising expenditures were collected from Leading National Advertisers. Market share data comes from the Market Share Reporter. The complete data set consists of more than 500 observations on quality, price, advertising, and market share for more than 50 brands in 12 product categories over periods averaging 10 years.

To estimate consumers’ valuations of quality and variety, we use a multiplicative market share model (Nakanishi and Cooper 1988) and estimate elasticities of market share. We use relative measures of price, advertising, and quality so that we can compare parameter estimates across categories. Relative price is calculated as the price of a brand divided by the average
price of brands in each category. Relative advertising and relative quality are calculated similarly. Thus, we propose the following model:

\[ MS_{ijt} = e^{b_{ij}} p_{ijt}^{b_{ij}} q_{ijt}^{b_{ij}} a_{ijt}^{b_{ij}} \sum_{k=1}^{n_{j}} D_k c_{kj} + u_{ijt} \]  

(1)

where \( MS_{ijt} \) is the market share of brand \( i \) in product category \( j \) at time \( t \)

\( p_{ijt} \) is the relative price of brand \( i \) in product category \( j \) at time \( t \)

\( q_{ijt} \) is the relative quality of brand \( i \) in product category \( j \) at time \( t \)

\( a_{ijt} \) is the relative advertising of brand \( i \) in product category \( j \) at time \( t \)

\( D_k \) is the dummy of brand \( k \) and \( n_{j} \) is the number of brands in product category \( j \)

\( b_{0j}, b_{1j}, b_{2j}, b_{3j}, \text{ and } c_{kj} \) are parameters of the model such that \( c_{kj} > 0 \)

and \( u_{ijt} \) is the error component.

Since estimation of equation (1) might be biased because of omitted variables or possible autocorrelation, we include a lagged market share term in the model (Jacobson and Aaker 1985). In addition, we linearize equation (1) and then estimate equation (2).

\[ \ln MS_{ijt} = b_{0j} + b_{1j} \ln p_{ijt} + b_{2j} \ln q_{ijt} + b_{3j} \ln a_{ijt} + b_{4j} \ln MS_{ij(t-1)} + \sum_{k=1}^{n_{j}-1} c_{kj} D_k + u_{ijt} \]  

(2)

Consumer valuation of quality in product category \( j \) can be measured by quality elasticity of market share in category \( j \) which is \( b_{2j} \). Consumer valuation of variety in product category \( j \) can be measured by \( \sum_{k=1}^{n_{j}-1} c_{kj} \), the average brand-specific parameter for each category. In essence, the brand-specific constants represent product valuations after accounting for quality, price and advertising effects, which theoretically corresponds to variety-induced preferences. Note that the constraint \( c_{kj} > 0 \) ensures that the brand level parameters are calculated using the brand with the minimum parameter as the base. This constraint enables more meaningful comparison of averages across categories.

Since we use pooled time-series cross-sectional data, our estimation uses a generalized least squares regression approach with one-way effects such that
\[ u_{ijt} = e_i + \epsilon_{ijt} \]  

where \( \epsilon_{ijt} \) is a classical error term with zero mean and a homoscedastic covariance matrix. We estimate our model using SAS procedure TSCSREG.

In Table 2 we report consumer valuations of quality and variety for the 12 categories on which we were able to collect data. These data confirm our anecdotal beliefs that consumers have a high valuation of quality in disposable diapers and a high valuation of variety in laundry detergent. Next, we evaluate the impact of the model’s key variables on market performance.

---

Impact of Model Variables on Market Performance

We begin by presenting the average market share of pioneers in categories that are high and low on the three key model variables: vintage effects, consumer valuation of quality, and consumer valuation of variety (see Table 3). Pioneers’ market shares are based on 1999 data and the categories high and low on each variable are those scoring in the top one-third and bottom one-third on each variable.

The results in Table 3 are consistent with our model. Product categories with high vintage effects lead to lower market shares for pioneers; high valuation of quality leads to lower market shares for pioneers; and high valuation of variety leads to higher market shares for pioneers. Pioneers also have lower survival rates under high vintage effects and high (low) consumer valuation of quality (variety), consistent with our model’s implications that later entrants can more easily come to dominate pioneers under those market conditions. Note that some product categories have different combinations of high or low quality or variety valuations; e.g., categories with high quality valuation may have either low or high variety valuations. We
therefore indicate in Table 3 results under high versus low ratios of the quality-to-variety valuations, showing the expected relationships.

Now we consider the impact of all three variables simultaneously. Since many market pioneers have failed in these 12 categories and now have 0% market share, we sought a more meaningful dependent variable to provide a better measure of long-term success in these categories. Thus, we identified the market share leader in all 12 categories in 1961, 1981, and 2001. We use the number of different leading brands in each category in these three periods as a measure of leadership instability. Based on our theoretical model, we expect that leadership instability will be positively related to vintage effects and consumer valuation of quality, and negatively related to consumer valuation of variety. Since pioneers are de facto leaders at the start of each category, we believe that our analysis of leadership instability provides a reasonable test of our theoretical model.

In Table 4, we report the results of an OLS regression. As expected, vintage effects and consumer valuation of quality are both positive and significant. Consumer valuation of variety is negative, although not significant. When combined with our earlier case studies, market share and survival analyses, these results provide good empirical validation of our theoretical model, at least for the categories we consider.

Conclusions
We conclude by summarizing our primary findings, discussing their implications for managers, and suggesting future directions for researchers.

Several important findings emerge from our study of sequential market entry:

- Models of pioneering should consider important sources of disadvantage as well as sources of advantage. Our model includes a well-accepted source of advantage, market preemption. In addition, we consider an important potential disadvantage, vintage effects from improving technology. By considering both of these important effects, we are able to examine the conditions under which pioneers are more likely to succeed and fail. Our model demonstrates that vintage effects can eliminate a pioneer’s advantage from preemption.

- In particular, our model illustrates that the magnitude of a pioneering (dis)advantage depends upon consumers’ valuations for product variety and quality. Higher consumer valuation for quality acts as leverage for the vintage effect, enabling later entrants to translate a quality advantage into even greater market share rewards. Higher valuation for variety, however, plays to the pioneer’s preemptive strength. For a fixed relative valuation of variety to quality, the pioneer’s preemptive advantage allows it to reach a given market share or profit objective with substantially less quality improvement, compared to the quality advantage needed by a later entrant hoping to achieve a similar market share or profit objective. Three case studies illustrate these key elements of the model.

- Even if the preemptive pioneer advantage becomes stronger as later entry is delayed, vintage effects can help patient later entrants overtake the pioneer as technology improves. We show that the entry decision depends not only upon how quickly the preemption and vintage effects change over time, but also on how consumers value product variety and quality. Later entrants are more likely to succeed when consumers value quality over variety, and high quality valuations prompt the later entrant to delay entry.

- Based on an extensive data set of long-term price changes in 36 categories, we find that the price-decline measure of vintage effects is significantly higher for durable goods than non-durable goods. The average annual real price decline is 5.4% for durable goods, while it is only 0.5% for non-durable goods.
• Analysis of brand-level longitudinal data for 12 of the 36 product categories confirms our model’s predictions. We find fewer rewards for market pioneers in the presence of strong vintage effects. Pioneers also have lower market shares and survival rates when consumers have high valuations of quality or low valuations of variety. We also find that market leaders are less able to maintain leadership under stronger vintage effects and higher consumer valuation of quality (lower variety valuation led to greater leadership instability as predicted, but was not significant). Overall the empirical results support the model and its implications. Our study is the first general test of improved later entrant performance in markets where vintage effects coupled with favorable quality and variety consumer valuations can help overcome any pioneering preemptive advantage.

Implications for Managers

Our findings have three primary implications for managers. First, later entry itself can be an advantage. When pioneers enter at the optimal position, they establish important preemption advantages. However, later entrants benefit from advancing technology that enables them to provide higher quality at lower cost. This benefit can overcome an advantage from preemption under many conditions. This mechanism is more likely when pioneers are unable to switch to newer technology due to economic or managerial commitments and when technology is advancing rapidly.

A second important implication is that the rewards of pioneers and later entrants depend critically on consumer valuations of quality and variety. Managers should realize that successful pioneers are more likely to persist when variety is important. However, later entrants are more likely to be successful when consumers value quality. Understanding the impact of different environmental conditions is critical for managers to be able to allocate their resources for maintaining or attaining leadership. Variety valuation helps pioneers defend against later entrant quality advantages and generate profits. Higher quality valuations help later entrants more easily overtake pioneers, although later entrants may choose to delay entry to improve quality further.
A final implication is that pioneers that do not enter at the optimal position suffer a double disadvantage. Later entrants have an easier opportunity to enter at the optimal position once the pioneer has resolved some of the uncertainty associated with the new market. Also, later entrants receive a greater benefit from vintage effects. Whether preemptive or quality benefits accrue to the pioneer or later entrant, the ability to leverage these advantages depend greatly on the consumer valuations.

**Limitations and Directions for Future Research**

Our study’s findings as well as its limitations offer several opportunities for future research. Our model provides a preemption advantage for pioneers which is obtained by locating at the optimal position. While it is highly desirable to enter at the optimal location, it is very difficult to do so in practice. The vintage effect mechanism of pioneer disadvantage is captured in the model by allowing cost-of-quality to differ between the pioneer and later entrant. Although the model is easily extended to other types of pioneering (dis)advantages, the model does not consider every possibility. Future research could examine other strategic factors, such as marketing efforts or investments to improve quality or deter entry. Future research could also collect data on the positioning of market entrants to evaluate whether pioneers are able to capture this opportunity by positioning at the optimal location.

Our model extension on entry timing amplifies the importance of consumer valuations, with some anecdotal support. Some research has shown that pioneers have a greater advantage the longer they are in the market before competitors enter (Brown and Lattin 1994; Huff and Robinson 1994). This result is consistent with the growing “subjective” advantage of the pioneer as portrayed in our entry timing model extension. These studies use data from frequently purchased consumer goods, where on average we would expect variety to be more important, and hence pioneer advantages are better able to grow. For a quality-value example,
Berndt et al. (1995) study the anti-ulcer drug market and find a significant deterioration in the pioneer’s market share over time, down to 21% compared to 54% for the second entrant. The second entrant was able to overtake the pioneer by producing higher quality (fewer adverse interactions with other drugs and greater effectiveness for more types of ulcers). Consistent with our model, quality advantages in the likely presence of high consumer valuation of quality enabled a later entrant to overcome a preemptive pioneer advantage. Empirical validation of our model’s entry timing results would help clarify the relevant strategic implications.

Our operational measure of vintage effects is limited because it focuses on price instead of cost-of-quality directly. While we believe that these data provide a conservative test of our model, additional measures of vintage effects would likely provide other new insights. While our study is the first to demonstrate superior later entrant performance in markets with strong vintage effects, other anecdotal evidence beyond our case studies supports our finding. In particular, Robinson (1988) and Robinson and Fornell (1985) find that pioneer advantage is stronger in consumer markets than industrial markets. While there is no single explanation for this result, stronger vintage effects for industrial goods are one potential explanation.

Although we were able to collect extensive data on variety and quality valuations for model testing, our data applies to a small set of 12 product categories, and exhibits substantial failure rates for pioneers within those categories. However, the results for the pioneer’s market share, survival rate, and ability to maintain leadership are all consistent with our theory. Empirical validation would be aided by more direct measurement of the product attributes and consumer valuations relevant to each category.

Our study focuses on vintage effects and consumer valuations for quality and variety as potential explanations for later entrants out-performing pioneers. Other potential explanations should be considered as well. Since the long-term rewards of pioneers in our data are fairly low,
other important factors opposing pioneers may also be at work. We hope that our theoretical and empirical results can motivate further research on the important drivers of pioneering advantage and disadvantage.
Appendix

PROPOSITION A1. For the sequential entry, variety-quality model, define a measure of the cost-of-quality difference between the two firms as:

\[ Q = \frac{b^2}{4a} \left( \frac{1}{c_1} - \frac{1}{c_2} \right) \]

Note that \( Q \) is positive if the pioneer (Firm 1) has a lower cost-of-quality than the later entrant (Firm 2). The unique, pure-strategy equilibrium is:

For \( Q \leq -25/16 \), the later entrant captures the entire market (the pioneer will exit the market).

For \( Q \geq 5/2 \), the pioneer captures the entire market (the later entrant will not enter).

For \( -25/16 < Q < 5/2 \), the equilibrium quality levels, prices and demand levels are:

\[
\begin{align*}
q_1^* &= b/2c_1 \\
p_1^* - c_1q_1^* &= a\left(2 + y_1^* + y_2^* + Q\right)/3 \\
Demand_1^* &= \left(2 + y_1^* + y_2^* + Q\right)/6 \\
q_2^* &= b/2c_2 \\
p_2^* - c_2q_2^* &= a\left(4 - y_1^* - y_2^* - Q\right)/3 \\
Demand_2^* &= \left(4 - y_1^* - y_2^* - Q\right)/6
\end{align*}
\]

The equilibrium variety levels are given by:

For \( -25/16 < Q \leq \sqrt{18} - 7/2 \): \[ y_1^* = 15 - Q - 6\sqrt{6 - Q} \quad \text{and} \quad y_2^* = 1 \]

For \( \sqrt{18} - 7/2 \leq Q \leq 2\sqrt{18} - 3/3 \): \[ y_1^* = 0.5 \quad \text{and} \quad y_2^* = \sqrt{18} - Q - 5/2 \]

For \( 2\sqrt{18} - 3/3 \leq Q < 5/2 \): \[ y_1^* = 0.5 \quad \text{and} \quad y_2^* = 3\sqrt{4Q + 26} - Q - 29/2 \]

Given the equilibrium quality levels, the parameter \( Q \) can be expressed as

\[ Q = \frac{b}{2a} \left( q_1^* - q_2^* \right) \]

PROOF OF PROPOSITION A1. Solve by backward induction, considering only pure strategies. For the pricing subgame (the last stage of the game), the equilibrium solution is similar to that in d’Aspremont et al. (1979) for the linear Hotelling model; namely, the equilibrium prices must be such that neither firm has an incentive to price-undercut its rival to capture the entire market, and each firm will have a positive market share in equilibrium. First find the demand faced by each firm, given every consumer buys a single unit. The consumer indifferent between the two products is located at:
\[ \theta_0 = \frac{1}{2a} (ay_1 + ay_2 + p_2 - p_1 + bq_1 - bq_2) \quad \text{for } y_1 \leq \theta_0 \leq y_2 \]

Firm 1 will capture the entire market if \( U_1(\theta) > U_2(\theta) \) \( \forall \theta \), and likewise firm 2 will capture the entire market if \( U_2(\theta) > U_1(\theta) \) \( \forall \theta \). Firm 1’s demand is therefore

\[
D_1 = \begin{cases} 
1 & \text{if } p_1 < p_2 - a(y_2 - y_1) + b(q_1 - q_2) \\
0 & \text{if } p_1 > p_2 + a(y_2 - y_1) + b(q_1 - q_2) \\
\theta_0 & \text{otherwise}
\end{cases}
\]

and demand of firm 2 is obviously \( D_2 = 1 - D_1 \). The two firms will have no incentive to deviate in prices in the pricing stage if:

\[
\pi_1(y_1, y_2, q_1, q_2, p_1^*, p_2^*) > p_2^* - a(y_2 - y_1) + b(q_1 - q_2) - c_1q_1^2 \\
\pi_2(y_1, y_2, q_1, q_2, p_1^*, p_2^*) > p_1^* - a(y_2 - y_1) - b(q_1 - q_2) - c_2q_2^2
\]

Assuming these conditions hold, each firm sets price to maximize profits, which gives

\[
p_1^* = \left[ a(2 + y_1 + y_2) + b(q_1 - q_2) + 2c_1q_1^2 + c_2q_2^2 \right]^{\frac{1}{3}} \\
p_2^* = \left[ a(4 - y_1 - y_2) - b(q_1 - q_2) + 2c_2q_2^2 + c_1q_1^2 \right]^{\frac{1}{3}}
\]

The corresponding profit functions then become

\[
\pi_1(y_1, y_2, q_1, q_2, p_1^*, p_2^*) = \frac{1}{18a} \left[ a(2 + y_1 + y_2) + b(q_1 - q_2) - c_1q_1^2 - c_2q_2^2 \right]^3 \\
\pi_2(y_1, y_2, q_1, q_2, p_1^*, p_2^*) = \frac{1}{18a} \left[ a(4 - y_1 - y_2) - b(q_1 - q_2) - c_2q_2^2 - c_1q_1^2 \right]^3
\]

Consider now the location and quality stage for Firm 2. The optimal quality level is:

\[ q_2^* = b/2c_2 \]

Firm 2’s first-order condition of maximizing profits with respect to variety location \( y \) is strictly negative, such that it would like to locate as close to Firm 1 as possible. Similarly, for Firm 1’s location and quality stage, the optimal quality is:

\[ q_1^* = b/2c_1 \]

and Firm 1 wishes to locate as close to Firm 2 as possible. Profits for both firms are strictly concave in quality, and there is no strategic distortion in that optimal quality levels are strictly a function of a firm’s own cost-of-quality. Therefore, if the firms’ variety locations are such that the pricing non-deviation constraints hold, a pure-strategy equilibrium will exist. We thus find optimal variety locations such that the price non-deviation constraints are satisfied and that
neither firm has an incentive to deviate in variety in order to steal the entire market. We add the reasonable technical assumption that if a firm deviates in its variety location such that it then has an incentive to try and capture the entire market, the opposing firm will retaliate in the pricing stage by cutting price to marginal cost (e.g., see Novshek 1980). This condition merely states that a firm will not deviate in variety location and attempt to capture the entire market unless and until the opposing firm’s price retaliation threat is no longer credible. A firm’s retaliation threat is not credible if the firm would need to price below marginal cost to dissuade the competing firm from deviating.

Define the parameter $Q$ as

$$Q = \left[ b(q_1 - q_2) - c_1 q_1^2 + c_2 q_2^2 \right] a$$

The non-deviation conditions for $(p_1^*, p_2^*)$ to be a price equilibrium can be written as:

$$\begin{align*}
(2 + y_1 + y_2 + Q)^2 & \geq 12(2 + y_1 - 2y_2 + Q) \\
(4 - y_1 - y_2 - Q)^2 & \geq 12(1 + 2y_1 - y_2 - Q)
\end{align*}$$

It is easy to show that the second condition, corresponding to Firm 2 having no incentive to price undercut, is critical whenever

$$y_1 + y_2 \geq 1 + Q/2$$

Further note that, although Firm 1 would like to make $y_1 + y_2$ as large as possible, Firm 1 will never choose $y_1 > 1/2$. If it did so, Firm 2 would locate on the opposite side of the variety line ($y_2 < 1/2$) and Firm 1 will be worse off. Consistent with our 2-firm game with accommodating entry, we only consider variety locations where $y_1 \leq 1/2$ and $y_2 \geq 1/2$.

Firm 1’s preemptive first-mover advantage lies in gaining an advantageous variety location over its later entrant competitor. Consider a range of $Q$ such that Firm 2 is forced to take the extreme variety position $y_2 = 1$. Firm 1 will choose a variety level such that the second non-deviation constraint binds, or

$$y_1^2 + (2Q - 30)y_1 + (9 + 6Q + Q^2) = 0 \implies y_1^* = 15 - Q - 6\sqrt{6 - Q}$$

This optimal variety location for Firm 1 is valid until the firm can locate in the middle of the variety line, which occurs at $Q = \sqrt{18} - 7/2$. For smaller values of $Q$, the threat of retaliation gives Firm 2 no incentive to deviate in variety location as long as $Q > -25/16$. For $Q \leq -25/16$ the pioneer has such a quality disadvantage that its threat of price retaliation is no longer credible, and Firm 2 can locate at the variety midpoint and capture the entire market (Firm 1 will exit). Thus, for the range $-25/16 < Q \leq \sqrt{18} - 7/2$, $y_2^* = 1$ and $y_1^* = 15 - Q - 6\sqrt{6 - Q}$, and it is easy to verify that the non-deviation conditions hold and that both firms get positive profits.
For $Q \geq \sqrt{18} - 7/2$ Firm 1 stays at the variety middle by assumption, such that the binding non-deviation constraint is used to determine Firm 2’s variety location. For the region of $Q$ where the second non-deviation condition still binds we find that

$$y_1^* = \frac{1}{2} \quad \text{and} \quad y_2^* = \sqrt{18} - Q - 5/2 \quad \text{for} \quad \sqrt{18} - 7/2 \leq Q \leq 2\left(\sqrt{18} - 3\right)/3$$

For larger values of $Q$, the critical constraint switches to Firm 1 having no incentive to price undercut. We then find that

$$y_1^* = \frac{1}{2} \quad \text{and} \quad y_2^* = 3\sqrt{4Q + 26} - Q - 29/2 \quad \text{for} \quad 2\left(\sqrt{18} - 3\right)/3 \leq Q < 5/2$$

noting that Firm 2 cannot receive positive profits whenever $Q \geq 5/2$. One can again verify that the non-deviation constraints are satisfied, and that neither firm has an incentive to deviate in variety locations since the threat of price retaliation is credible. Since the non-deviation conditions are satisfied and one of the constraints always binds, uniqueness is assured by strictly concave profit functions in price and quality. Comparative statics results of Propositions 1a, 1b and 1c follow directly from the optimal solution. Q.E.D.
References


Figure 1
Equilibrium Market Shares for Variety-Quality Model
<table>
<thead>
<tr>
<th>Product Category</th>
<th>Market Pioneer</th>
<th>Current Leader</th>
<th>Annual % Price Decline * (Intra-category average)</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-durable Goods</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-0.96</td>
<td>1983-1999</td>
</tr>
<tr>
<td>2. Laundry Detergent</td>
<td>Dreft (1933)</td>
<td>Tide</td>
<td>-0.01</td>
<td>1951-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1974-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1961-1999</td>
</tr>
<tr>
<td>4. Frozen Dinners</td>
<td>Swanson (1946)</td>
<td>Stouffer</td>
<td>1.33 1.25 (1.29)</td>
<td>1954-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1956-1999</td>
</tr>
<tr>
<td>7. Diet Cola</td>
<td>Kirsch’s No-cal Cola (1952)</td>
<td>Diet Coke</td>
<td>0.27</td>
<td>1961-1999</td>
</tr>
<tr>
<td>9. Dandruff Shampoo **</td>
<td>Fitch’s (1919)</td>
<td>Head &amp; Shoulders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Cereal</td>
<td>Granula (1863)</td>
<td>General Mills</td>
<td>-0.36 0.42 (0.03)</td>
<td>1937-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1937-1999</td>
</tr>
<tr>
<td>11. Canned Fruit</td>
<td>Libby, McNeill, Libby (1868)</td>
<td>Del Monte</td>
<td>0.49 0.36 (0.43)</td>
<td>1939-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1939-1999</td>
</tr>
<tr>
<td>12. Chocolate</td>
<td>Whitman’s (1842)</td>
<td>Hershey/M&amp;M Mars</td>
<td>-0.43 0.00 (-0.22)</td>
<td>1969-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1974-1999</td>
</tr>
<tr>
<td>13. Vegetable Shortening</td>
<td>Crisco (1911)</td>
<td>Crisco</td>
<td>-0.01</td>
<td>1954-1999</td>
</tr>
<tr>
<td>14. Canned Milk</td>
<td>Borden (1860)</td>
<td>Carnation</td>
<td>-0.79</td>
<td>1943-1999</td>
</tr>
<tr>
<td>15. Chewing Gum</td>
<td>Black Jack/American Chicle (1871)</td>
<td>Wrigley</td>
<td>0.62 0.49 -0.06 0.47 (0.38)</td>
<td>1920-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1955-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1929-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1971-1999</td>
</tr>
<tr>
<td>16. Flashlight Batteries</td>
<td>Bright Star (1909)</td>
<td>Duracell</td>
<td>-0.41</td>
<td>1938-1999</td>
</tr>
<tr>
<td>17. Soft Drinks</td>
<td>Vernors (1866)</td>
<td>Coca-Cola</td>
<td>0.08 0.42 (0.25)</td>
<td>1886-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1886-1999</td>
</tr>
<tr>
<td>18. Cola</td>
<td>Coca-Cola (1886)</td>
<td>Coca-Cola</td>
<td>0.08 0.42 (0.25)</td>
<td>1886-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1886-1999</td>
</tr>
<tr>
<td>Non-durables Average</td>
<td></td>
<td></td>
<td>0.50%</td>
<td></td>
</tr>
<tr>
<td><strong>Durable Goods</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------------</td>
<td>-------</td>
<td>-------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.2</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(11.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.0</td>
<td>(7.3)</td>
</tr>
<tr>
<td>5. Fax Machines</td>
<td>Xerox (1964)</td>
<td>Sharp</td>
<td>20.3</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>27.7</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(18.1)</td>
</tr>
<tr>
<td>6. Personal Computer</td>
<td>MITS (1975)</td>
<td>Dell</td>
<td>1.9</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.4</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(9.4)</td>
</tr>
<tr>
<td>8. Color TVs</td>
<td>RCA (1954)</td>
<td>RCA</td>
<td>5.4</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.4</td>
<td>(5.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Cameras</td>
<td>Daguerrotype (1839)</td>
<td>Kodak</td>
<td>1.7</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.3)</td>
</tr>
<tr>
<td>10. Safety Razors</td>
<td>Star (1876)</td>
<td>Gillette</td>
<td>3.0</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(5.0)</td>
</tr>
<tr>
<td>11. Sewing Machines</td>
<td>4 firms (1849)</td>
<td>Singer</td>
<td>0.7</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3.8)</td>
</tr>
<tr>
<td>14. Telephone</td>
<td>Bell (1877)</td>
<td>AT&amp;T</td>
<td>9.8</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.9</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(8.1)</td>
</tr>
<tr>
<td>16. Video Games</td>
<td>Magnavox Odyssey (1973)</td>
<td>Sony</td>
<td>4.9</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Category</td>
<td>Period</td>
<td>Number of Brands</td>
<td>Valuation of Quality</td>
<td>Valuation of Variety</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------</td>
<td>------------------</td>
<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Disposable Diapers</td>
<td>1989-1999</td>
<td>3</td>
<td>4.31</td>
<td>0.06</td>
</tr>
<tr>
<td>Personal Computers</td>
<td>1989-1999</td>
<td>6</td>
<td>3.81</td>
<td>0.29</td>
</tr>
<tr>
<td>Flashlight Batteries</td>
<td>1989-1999</td>
<td>3</td>
<td>3.32</td>
<td>1.55</td>
</tr>
<tr>
<td>Copy Machines</td>
<td>1989-1999</td>
<td>2</td>
<td>2.42</td>
<td>0.24</td>
</tr>
<tr>
<td>Camcorders</td>
<td>1989-1999</td>
<td>4</td>
<td>2.11</td>
<td>0.21</td>
</tr>
<tr>
<td>Color TV</td>
<td>1989-1999</td>
<td>4</td>
<td>1.73</td>
<td>0.44</td>
</tr>
<tr>
<td>Video Recorders</td>
<td>1989-1999</td>
<td>5</td>
<td>1.17</td>
<td>0.31</td>
</tr>
<tr>
<td>Microwave Ovens</td>
<td>1989-1999</td>
<td>5</td>
<td>1.45</td>
<td>0.38</td>
</tr>
<tr>
<td>Dishwashing Liquid</td>
<td>1990-1999</td>
<td>5</td>
<td>1.45</td>
<td>0.13</td>
</tr>
<tr>
<td>Liquid Laundry Detergent</td>
<td>1990-1999</td>
<td>6</td>
<td>0.89</td>
<td>0.44</td>
</tr>
<tr>
<td>Laundry Detergent</td>
<td>1990-1999</td>
<td>5</td>
<td>0.51</td>
<td>0.58</td>
</tr>
<tr>
<td>Tires</td>
<td>1990-1999</td>
<td>5</td>
<td>0.37</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* The data quantify price declines, such that a negative number signifies an average price increase over time.
** Despite an extensive search, we were unable to obtain an early price for this product. We used traditional sources and even contacted Procter and Gamble. They were not able to provide a price either.
Table 3
Average Performance of Pioneers for Different Types of Product Categories

<table>
<thead>
<tr>
<th>Type of Category</th>
<th>Market Share (%)</th>
<th>Survival Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Vintage Effects</td>
<td>6.8</td>
<td>50</td>
</tr>
<tr>
<td>Low Vintage Effects</td>
<td>12.8</td>
<td>58</td>
</tr>
<tr>
<td>High Consumer Valuation of Quality</td>
<td>0.3</td>
<td>25</td>
</tr>
<tr>
<td>Low Consumer Valuation of Quality</td>
<td>3.0</td>
<td>50</td>
</tr>
<tr>
<td>High Consumer Valuation of Variety</td>
<td>8.3</td>
<td>75</td>
</tr>
<tr>
<td>Low Consumer Valuation of Variety</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>High Ratio of Quality-to-Variety Valuation</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>Low Ratio of Quality-to-Variety Valuation</td>
<td>3.0</td>
<td>50</td>
</tr>
</tbody>
</table>

Note: All of these results are robust to using a median split of the data except for the market share results on consumer valuation of quality. In this case, a high market share for the pioneer immediately above the median raises the average from 0.0% to 3.5%.

Table 4
Parameter Estimates for Model of Leadership Instability

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Standard Error</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.98</td>
<td>0.33</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Vintage Effects</td>
<td>0.083</td>
<td>0.036</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Consumer Valuation of Quality</td>
<td>0.42</td>
<td>0.10</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Consumer Valuation of Variety</td>
<td>-0.14</td>
<td>0.34</td>
<td></td>
</tr>
</tbody>
</table>
Endnotes

1 An unpublished paper by Boulding and Christen (1997) presents empirical evidence that pioneers on average have higher production costs than later entrants, consistent with our modeling of vintage effects.

2 If costs of imitation are less than that for innovation, this could further increase the pioneer cost disadvantage.

3 This is consistent with the later entrant’s production cost being \( c_2(t) = (a_1 + a_2 t)^{-1} \). Note that \( Q \) is only implicitly changing over time, since \( Q \) becomes fixed once the later entrant decides to enter.

4 A complete list of references used in preparing these case studies is available from the authors.

5 Since not all of these categories have existed since 1961, we also evaluated an alternative dependent variable. This variable is the number of transitions in leadership observed divided by the number of transitions possible. Results with the alternative dependent variable are the same as those we present in terms of parameter signs and significant parameters.

6 The issue of mixed-strategy equilibria for Hotelling and other models with discontinuous payoff functions is considered by Dasgupta and Maskin (1986).

7 Our assumption that the pioneer stays at the variety midpoint results in profits being a constant in this region of \( Q \). Note this is clearly due to the manner in which the variety distribution is modeled. Alternatively, we could assume that the pioneer may locate at \( y > 0.5 \) and introduce (at very low cost) one or more products at the lower variety levels, preventing the later entrant from entering there. This would make the later entrant always locate at \( y = 1 \), while the pioneer’s optimal location (and profits) will be increasing in \( Q \). See Tyagi (2000) for comparison. The intuition and fundamental results of the model remain unchanged, however. This constant-profit occurrence is typical of linear variety on a finite line. Indeed, for the linear Hotelling model discussed in d’Aspremont et al. (1979), assuming the two firms are located symmetrically on the Hotelling line in the outer quartiles (such that price equilibrium exists), the firms will have identical profits regardless of which locations are considered.