Churn, Baby, Churn:
Strategic Dynamics Among Dominant and Fringe Firms in a Segmented Industry*

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Abstract

This paper integrates and extends the literatures on industry evolution and dominant firms to develop a dynamic theory of dominant and fringe competitive interaction in a segmented industry. It argues that a dominant firm, seeing contraction of growth in its current segment, enters new segments to exploit its technological strengths, but segments sufficiently distant to avoid cannibalization. The dominant firm acts as a low-cost Stackelberg leader, driving down prices and triggering a sales takeoff in the new segment. We identify a "churn" effect associated with dominant firm entry: fringe firms that precede the dominant firm into the segment tend to exit the segment, while new fringe firms enter, causing a net increase in the number of firms in the segment. As the segment matures and sales decline in the segment, the process repeats itself. We examine the predictions of the theory with a study of price, quantity, entry and exit across 24 product classes in the desktop laser printer industry from 1984 through 1996. Using descriptive statistics, hazard rate models, and panel data methods, we find empirical support for most of the theoretical predictions.

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Churn, Baby, Churn: Strategic Dynamics Among Dominant and Fringe Firms in a Segmented Industry

I. Introduction

The literature on industry evolution finds that the number of firms in an industry increases to a peak and then declines to a roughly steady-state number. This pattern has been attributed to competition and legitimation (Hannan and Carroll 1992), different cost structures of entrants and incumbents (Jovanovic and MacDonald 1994), and the technological prowess of incumbents relative to entrants (Klepper 2002). Recent research, which has analyzed this pattern with more detailed data, has noted a "sales takeoff" accompanying the increase in the number of firms in the industry. This has generally been attributed to the entry of firms with a lower (marginal) cost position. These firms shift the supply curve down and consequently cause the quantity of goods sold to increase (Bass 1980, Stoneman and Ireland 1983, Gort and Klepper 1982, Goldner and Tellis 1997). More recent work has argued that the sales takeoff is due not only to a shift in the supply curve, but also to an outward shift in the demand curve (Agarwal and Bayus 2002).

While these outcomes have been well documented (Gort and Klepper 1982; Agarwal & Gort 2002), the analysis of the causal mechanisms remains somewhat incomplete. Because data are usually aggregated at a high level in cross-industry studies focusing on industry-level dynamics, the current literature has not been able to identify one of the key causal mechanisms for a sales takeoff: entry or expansion by a dominant firm. Similarly, this industry-level focus has precluded study of the evolution of segments within an industry.[1]

This paper extends the industry evolution literature by developing a theory of the evolution of *segmented* industries, an area in which there is very little extant theory. A dominant firm expands within its existing segment until growth in that segment slackens. This causes the firm to selectively enter new segments in which it can exploit its technological capabilities but avoid cannibalization of its current products. The dominant firm acts as a Stackelberg leader, triggering a price decline, sales takeoff, and change in the pattern of entry and exit by fringe firms in that segment. This dynamic cycle repeats itself when growth in the new segment falls. To test the predictions of the theory, we adopt a novel empirical approach to explore dominant firm entry and its consequences for fringe firms. We study a single industry – the desktop laser printer industry – that is composed of several identifiable market segments or product

[1] The organizational ecology literature has studied density dependence in niches within a population. However, this is primarily viewed through the lens of legitimation and competition, rather than through the economic dynamics of industry evolution.

classes. By studying the entry of the same dominant firm into different segments at different points in time, we are able to conduct multiple "experiments" while holding basic features of the industry and the players constant. This allows us to more finely pinpoint the sources of variation in the data, and test theoretical predictions at the intra-industry level.

Our paper integrates economic and management theory on industry evolution to make three contributions to the literature. First, rather than examine dynamics at the aggregate industry level, our work examines how an industry evolves in different segments, and to what extent the theoretical predictions and empirical regularities found in the aforementioned literature inform the way in which segments develop in an industry. The evolution of multiple segments allows relationships between related segments to be considered through panel-data methods, and also allows us to extend theory to a more fine-grained level than this literature has previously considered.

Second, using segment-level microdata that have not been employed before in studies of this type, we shine new light on stylized facts from the industry evolution and dominant firm literatures. We show that the simultaneous or delayed correlation between entry and sales found in other studies is not due solely to the entry of fringe firms moving the supply curve or shifting demand. Rather, the entry of the dominant firm alters supply and/or demand, leading to price declines and the sales takeoff. The strategic selection of segments to enter by the dominant firm can have a significant effect on *whether* a sales takeoff occurs. With respect to the literature on the dominant firm, theoretical models typically begin with the formation of such a firm, and explore theoretically or empirically how such a firm defends its position by applying dynamic limit pricing to manage the tradeoff between high current profits and increased future competition (Kamien and Schwartz 1971; Caves, Fortunato and Ghemawat 1994). In this sense, the literature is static and usually considers the dominant firm solely in a defensive posture. Integrating these literatures with a comprehensive dataset on the laser printer industry allows us to provide a much more complete picture of the sales takeoff, dominant firm behavior, and industry evolution.

Third, the paper explores the behavior and heterogeneity of fringe firms. We show that once the dominant firm enters, a swarm of fringe firms follows the dominant firm in, most likely in expectation of the sales takeoff. At the same time, fringe firms that precede the dominant firm into the segment tend to exit after dominant firm entry. This suggests that some fringe firms develop strategies, structures, and capabilities suitable for success in the presence of a dominant firm – perhaps entailing a low-cost structure and an ability to take advantage of positive externalities created by the dominant firm – while other fringe firms configure their resources to succeed in the selection environment that exists before entry of a dominant firm. It is the entry and exit decisions by small firms before, during, and after dominant firm entry that causes a large amount of "churn" in the segment, with both entry and exit rates increasing with arrival of the dominant firm. Many of the exiting firms move to new segments, which the dominant firm may subsequently enter, thus leading to a churning of the same firms once again.

We conduct our empirical examination of the theoretical predictions using a dataset on the desktop laser printer industry from 1984 through 1996. Hewlett-Packard (HP) pioneered this industry in 1984, maintained at least 45% market share through 1996, and was widely perceived as the dominant player in the industry (de Figueiredo and Kyle 2005). We find empirical support for most of our theoretical predictions. In particular, we show that HP enters new segments when sales in its current segments stagnate or decline. The new segments that HP enters are related to HP's existing segments, in a manner suggesting that HP can exploit its existing technological capabilities in them (consistent with Klepper 2002). However, HP tends to avoid segments that are adjacent to its current segments in favor of segments further away, as long as such segments exist (consistent with Katz 1984). Furthermore, HP's entry is positively associated with a substantial price decline and a dramatic sales increase in a segment. Our evidence indicates that the dominant firm's entry triggers these changes in the segment. Finally, HP's entry precipitates a churning of fringe firms—increased entry rates following HP's entry, and increased exit rates for firms that entered the segment before HP entered. Although this study does not explore in detail the specific characteristics of fringe firms that encourage entry vs. exit upon the entry of a dominant firm, we hope that it will encourage further work in this area. More broadly, we hope that this study will open up new avenues of research on the strategic dynamics in segmented industries and on dominant firm-fringe firm interactions.

II. Theoretical Development and Framework

A. Preliminaries: Definition of Dominant Firm and Summary of Theory

In theoretical treatments of dominant firm behavior, dominance is defined by two characteristics: possession of a cost advantage and ability to price as a Stackelberg leader (Gaskins 1971; Caves et al. 1984). These characteristics imply that a dominant firm should be characterized by substantial market share. Empirical studies of dominant firms have identified dominance primarily by a firm's market share, with a share of 40% or 50% used as the typical threshold for dominance (Yamawaki 1985; White 1981;

Scherer and Ross 1990). We follow this convention, assuming in our theory that a dominant firm behaves as a low-cost Stackelberg leader and empirically identifying HP as the sole dominant firm in the laser printer industry based on a market share threshold of 40%.

With this definition, Figure 1 outlines the basic dynamic theoretical framework developed to explain the timing and direction of dominant firm entry and the response of fringe firms in a multi-segment market and in particular in the desktop laser printer industry. The next four sub-sections explore this framework in detail, but the basic outline is as follows: The dominant firm focuses on competing within its existing segment until it encounters reduced (expected) profitability in that segment, due to declining price and/or declining sales growth. This triggers the firm's entry into a new segment where it can better utilize its resources and investment. The selection of the new segment balances the tension between two basic forces: the firm's desire to exploit its innovative capabilities and its desire to avoid cannibalization of its current product portfolio. This causes a dominant firm to seek segments in which it can exploit its existing technological capabilities, but to skip neighboring segments to avoid cannibalization. When the dominant firm enters a new segment, it acts as a low-cost Stackelberg price leader, setting prices which are below those of the fringe firms already in the segment. This sparks a sales takeoff.

[INSERT FIGURE 1 ABOUT HERE]

Fringe firms, in turn, respond to the entry of the dominant firm. A set of fringe firms whose resources and capabilities are well suited for competing in the shadow of the dominant firm enter the segment on the heels of the dominant firm. However, incumbent fringe firms tend to exit the segment, presumably because their resources and capabilities, although appropriate for the pre-dominant firm period, are not well suited for the selection environment in the post-dominant firm era. This entry and exit behavior by these different types of firms results in a churn in the segment. Many of the exiting fringe firms continue to compete in other segments of the industry, often entering other segments as they exit the existing one. Ultimately, this segment experiences sales growth decline, and the cycle begins again.

B. Moving the Giant: What motivates the firms to move?

There are many motivating factors that may cause a dominant firm to seek new segments. We focus on three: the profitability of the current segment, the profitability of the potential segment, and the costs the firm faces in moving from one segment to another (costs of growth). Assume the dominant firm exists in a market segment (Segment 1). If the firm can expand costlessly, then the profitability of

Segment 1 should have no effect on the firm's decision to enter Segment 2; rather the firm moves into Segment 2 if the new segment is sufficiently attractive. For a firm that faces an increasing marginal cost of expansion in a given segment and a fixed cost of growing into new segments (e.g., Klepper 1996, 2002) the calculus is different. Assume the dominant firm must choose whether to produce only in Segment 1, enter and expand into Segment 2, or both. In this case, growing into Segment 2 occurs only if it is more attractive than expanding in Segment 1; thus the profitability of both the current and future markets drive the entry decision. In this case the firm will enter Segment 2 only if the discounted expected profits from Segment 2 minus the entry (or growth) costs are greater than the discounted expected profits from Segment 1.[2] Assuming the dominant firm's costs do not change over time within a segment, it is straightforward to see that as quantity or price drops in Segment 1, *ceteris paribus*, the hurdle for entering Segment 2 declines. That is, demand slowdown in one segment creates opportunities to grow in new segments (e.g., freeing factory capacity which can be used to grow into Segment 2).

H1: When there are growth costs, a market price or sales drop in a dominant firm's existing segment(s), *ceteris paribus*, makes it more likely to enter a new segment.

C. The dominant firm's entry decision: which segment?

How does a dominant firm choose which new segment to enter? Theoretical and empirical evidence on diversification indicates that a firm will enter new industries in which it can exploit its existing technological capabilities (Silverman 1999; Helfat & Lieberman 2002). In a formal treatment of this question, Klepper (2002) develops a model that describes industry evolution in terms of entry, innovation, growth, and exit of both new firms and diversifying firms in an industry. Much of Klepper's model turns on the differential research productivity of large firms, whereby those firms whose research efforts are more productive in an industry ultimately are more successful and are therefore more likely to enter in the first place. In a study of the television manufacturing industry, Klepper and Simons (2000) find support for this: producers of home radios (whose R&D expertise was directly useful in TV produc-

[2] This could be stated mathematically as follows: $E\left[\int_{t_0}^{\infty}(p_2 - c_2)q_2 \cdot dt\right] > E\left[\int_{t_0}^{\infty}(p_1 - c_1)q_1 \cdot dt\right] - m$, where p_i, c_i, q_i are the price, cost, and quantity of segment or class i, respectively, m is the cost of growth, and t_0 is the time of entry into class i.

tion) were among the earliest and most successful entrants to this industry; the larger and more experienced were these firms in home radios, the more likely their entry and success in television production.

To the extent that distinct product segments within an industry are conceptually similar to distinct industries, a similar pattern in segment entry will exist. Indeed, in a study of entry by incumbents into new "subfields" within the medical device industry, Mitchell (1989) found that these firms readily entered those subfields in which their firm-specific assets – including technological resources – provide value, and less readily entered subfields that would benefit less from their firm-specific assets.

H2: A firm will be more likely to enter a segment in which it can exploit its existing technological capabilities relative to segments in which it can not exploit these capabilities.

The above suggests that firms will enter segments where they can exploit economies of scope in the direction of their research capability. This is frequently taken to mean that a firm will choose to enter "nearby" or "proximate" segments, since a firm's research capability (and other assets) is likely to decrease in value as distance in product space increases (e.g. Wernerfelt and Montgomery 1988). However, there is a tension between the production-driven prediction above and concerns raised when considering the demand and competitive implications of segment entry. As a large literature on product line decisions (e.g., Moorthy 1984) and multiproduct entry (e.g., Brander & Eaton 1984) demonstrates, a firm that introduces products that are too proximate risks cannibalizing its own higher-margin products. This is exacerbated in the face of actual or potential competition: when a firm competes in multiple product segments in close proximity to each other such that they are partial substitutes, the firm has particularly weak incentives to behave aggressively with respect to any one of the product segments, since increased competition in that segment will not only reduce profits in that segment but will draw demand from the profitable proximate segment (Katz 1984; Judd 1985; Desai 2001). Recognizing this, potential and actual rivals can take advantage of the multiproduct firm's muted incentives. Consequently, while a dominant firm has a supply-side incentive to enter segments that are proximate, the firm also has a demand-side incentive to enter segments that are more distant, hence less directly substitutable. This implies that even as it enters new segments to exploit its research strength, the firm will have an incentive to avoid immediately adjacent segments. If this incentive is strong enough, then the firm will "skip" segments to avoid cannibalization of existing products and to remain credibly aggressive in each segment.

In contrast, to the extent that fringe firms are price-takers in their markets, a fringe firm will be less concerned about and a commitment to aggressive competitive behavior. We therefore expect fringe firms to be attracted to adjacent segments in order to best exploit their existing capabilities.

H3a: A fringe firm will be more likely to enter a segment adjacent to its existing segment(s) relative to segments further away.

H3b: A dominant firm will be less likely to enter a segment adjacent to its existing segment(s) relative to segments further away.

D. Prices and Demand

Previous studies on industry evolution have noted a substantial price decline and sales takeoff contemporaneous with, or subsequent to, the entry of new firms. These studies have attributed this price and quantity change to an outward shift in the supply curve caused by new, low cost entrants (Goldner and Tellis 1997, Bass 1980), and an outward shift in the demand curve caused by product improvements, expanded distribution, and increased consumer awareness (Agarwal and Bayus 2002). There is a third (not mutually exclusive) possibility: the demand curve can become more elastic over time. These three cases are briefly discussed below.[3]

Our theory takes these ideas and further explains a causal mechanism of the sales takeoff by introducing two new elements: a dominant firm and a segmented industry. To date, there is very little theory integrating industry evolution, dominant firms, and segmented markets creating, what we believe, is an opportunity to explore the dynamics of supply and demand in these cases. As such, our theory opens the door to further theoretical and empirical analysis of segment evolution.

In our theory, the dominant firm could cause all three of the demand and supply effects noted above. With respect to shifting the supply curve, the dominant firm maintains a marginal cost advantage derived from its ability to achieve higher economies of scale and its investment in cost-reducing R&D (Klepper 1996). The profit-maximizing price for a Stackelberg dominant firm is thus lower than the profit-maximizing price of a higher-cost fringe firm (Saloner et al 2001). Entry of the dominant firm into a segment will lead to a fall in equilibrium prices and, consequently, a sales takeoff.

With respect to shifting the demand curve, the dominant firm can increase product awareness through branding and advertising (Agarwal and Bayus 2002). Anderson and Tushman (1990) study the

[3] The electronic appendix develops these ideas in more detail as the basis for future avenues of research.

establishment of a dominant design in several industries and find that industry sales rise dramatically after a dominant design is established. Although this is distinct from the entry of a dominant firm, Anderson and Tushman note that the presence of a "dominant producer" can serve to convince customers that uncertainty about the industry's products has been resolved, and thus encourage them to increase their purchasing. This will also cause a sales takeoff because the demand shift will independently lead to more potential buyers entering the market. Note, however, that in the absence of an accompanying supply shift, the demand shift will actually cause prices to rise as unit sales increase.

Third, and related to the demand shift, a dominant firm's entry can also change the elasticity, or shape, of the demand curve in a segment by changing some buyers' willingness to pay more than others. This is distinct from shifting demand, as the change in elasticity has a distinct effect on optimal price. The demand curve will become more elastic if consumers with low willingness to pay increase their willingness to pay because of advertising, brand awareness, more legitimacy conferred to the segment (Haveman 1993). It is likely that smaller firms will have difficulty replicating this effect, given that new, small firms in new industries suffer from a legitimacy problem that slows sales (Aldrich and Fiol 1994).

Given that the increased willingness to pay associated with dominant firm entry is likely to affect those at the bottom of the demand curve, below the current equilibrium price point, the increasing elasticity of the demand by itself will have no effect on equilibrium sales or price. However, in conjunction with a supply shift, an increase in demand elasticity will magnify the attendant sales increase, while attenuating the price decline somewhat.

Thus, with a sufficiently large shift in demand, a sales takeoff can be associated with either a decline or increase in segment price. However, to the extent that the combination of supply shift and change in elasticity of demand exceed the demand shift, a sales takeoff will be associated with a decline in price. For the reasons described above, we expect the entry of a dominant firm into a segment to have a significant impact on both supply and elasticity of demand. Thus, we predict:

H4: After a dominant firm enters a segment, the price decline in that segment will accelerate.

H5. After a dominant firm enters a segment, sales in that segment will increase.

One concern might arise regarding these hypotheses. If the dominant firm is unusually good at forecasting future demand, then the sales takeoff could be a result of demand forecasting rather than demand creation, as posited by the theory. While we cannot definitively rule out the possibility of demand forecasting, we can point to a number of pieces of evidence that suggest this is not the case. We examine this logic in the empirical section and electronic appendix.

E. The Effect of the Dominant Firm's Entry on Fringe Firms

The final piece of the dynamic process is an analysis of what happens to fringe firms' entry and exit behavior when a dominant firm enters the segment. Current theoretical thinking on this topic yields ambiguous results. On one hand, the neoclassical model argues that dominant firms will drive out fringe firms because the dominant firm will be able to exploit of economies of scale in its operations. Moreover, as a dominant firm increases competitive pressure within a segment due to enhanced research productivity and its incentive to invest heavily in R&D, such entry should encourage fringe firm exit and discourage subsequent fringe firm entry (Klepper 1996). On the other hand, models of dominant firm behavior sometimes derive conditions in which the dominant firm will set a price umbrella that allows fringe firms in the market to prosper (Gaskins 1971), attenuating competitive pressure. Further, if entry by a dominant firm provides a positive signal about future demand in a given segment, then this should cause fringe firms to follow a dominant firm in the expectation that doing so will lead them to attractive segments (Haveman 1993). Thus, the dominant firm's entry might attract fringe firm entry and discourage exit.

We propose that the entry of the dominant firm causes both of these effects, leading to churn in the segment. There are two basic types of fringe firms: those whose capabilities and resources are well-suited to profiting in a segment with a dominant firm, and those whose capabilities and resources are not well-suited to this situation. When the dominant firm enters the segment, the competitive landscape changes. As often happens when a discrete event such as an innovation or regulatory change occurs, firms that were in the segment prior to the event are likely to exit because they are poorly equipped to face the new market conditions (Henderson and Clark 1990; Nickerson and Silverman 2003). Another set of firms will enter after the event to take advantage of the new conditions (Anderson and Tushman 1990). These firms are more likely to survive post-dominant firm entry because they are equipped to compete in such conditions. In this sense, fringe firms are not homogeneous as the literature has suggested (e.g. Hannan and Freeman 1989), but rather are heterogeneous in their resources and capabilities. Dominant firm entry causes the combination of these two events—the exit of incumbent fringe firms and entry of new fringe firms—resulting in substantial churn in the segment.[4]

H6: Dominant firm entry in a segment will be accompanied by a wave of fringe firm entry in that segment.

H7: *Ceteris paribus*, fringe firms that are in a segment before the dominant firm enters are more likely to exit the segment than firms which enter after the dominant firm enters.

The dynamic cycle of the interaction between the dominant and fringe firms then repeats itself as demand growth in the focal segment declines. Having developed a framework for thinking about the dynamics of dominant and fringe firm behavior in the context of a multi-segment industry's evolution, we turn to an empirical evaluation of the framework using data from the desktop laser printer industry.

III. The Laser Printer Industry

As the personal computer market expanded in the 1980s, so too did the market for desktop printers. Hewlett-Packard introduced the first desktop laser printer for the retail market in 1984. By the end of 1985, 17 firms had introduced 23 models of printers. At its peak in 1990, the industry had more than 100 firms, but by 1996 the number of firms had fallen to 87. HP maintained at least 45% market share each year between 1984 and 1996. Three other firms (Apple, Fujitsu, IBM/Lexmark) held between 10% and 20% market share for at least one year. No other firm held more than 6% market share during any year. Thus, HP is the sole dominant firm in this industry, and all other firms are fringe firms.[5]

A desktop laser printer is made, essentially, of three main components—laser engine, controller card (the electronics), and exterior features such as toner cartridge, feeder tray and plastic outside box. To create a printed page, the paper passes from the feeder tray to the laser engine, where the page is electrically charged. Fine-grain toner of the opposite charge is attracted to the paper, heated, and fused to the page by the fuser assembly of the laser engine. The paper is then ejected to the exterior paper tray. The controller card governs the process and provides the many features that a given laser printer offers.

[4] It is beyond the scope of this paper to identify the distinct characteristics of firms that precede vs. follow the dominant firm into a market. However, some possibilities are that followers have low-cost positions, high-quality products, or marketing structures designed to benefit from the positive externalities of the dominant firm's advertising expenditure.

[5] Our empirical results hold if we expand the definition of dominant firm to include Apple, Fujitsu, and IBM/Lexmark. Note that "fringe firm" indicates that a firm held a small market share *in this industry*. It does not necessarily mean that the firm itself is small. For example, Ricoh, Xerox, Kyocera, Okidata and Texas Instruments are defined as fringe firms in this industry, although they are large companies based on their other businesses.

The vast majority of laser printer producers purchase laser engines on the open market, choosing among 20 suppliers.[6] Canon is the dominant supplier, with 60% market share and 90% share of HP's purchases during the sample period. In contrast, the majority of laser printer producers make their own controller cards. Finally, virtually all laser printer makers purchase exterior features on the open market.

Two features of the laser printer industry are particularly salient to this study. First, the key characteristics of a laser printer are speed, measured in pages per minute (PPM), and resolution, measured in dots per inch (DPI). These are the two characteristics most prominently assessed in popular press rankings of printers (e.g., Consumer Reports 2005). Additionally, in a hedonic analysis of laser printers, de Figueiredo and Kyle (2005, 2006) find that speed and resolution are the two characteristics with the largest coefficients (with memory being the third important characteristic). Figure 2 provides the location in PPM-DPI space of each laser printer model introduced between 1984 and 1996. Each circle represents a printer model. A striking feature of this scatterplot is that printers are clustered tightly into distinct groups in this space. To identify the product classes, or segments, in this industry we pursued three avenues. First, we used the clustering in Figure 2 and accompanying statistical tests to identify segments where printers of roughly the same DPI and PPM are located together (see de Figueiredo and Kyle 2006 for more details). Second, we consulted trade journals and research reports to determine how experts segmented the industry. Finally, we met with firm managers to determine how they and their customers thought about segments and competition. From this we developed the 24 product classes in Figure 2.

Through 1996, there was little change in this classification scheme. Beginning in 1997, with technological advances in color printers, multifunction printers, and network printers, the segment definitions began to become more blurred. Hence, our data purposefully stop in 1996. These are the segments that we use to examine entry and exit patterns in these data. We have experimented with small changes to the segment definitions, and they do not change the qualitative results presented in this paper.

[INSERT FIGURE 2 ABOUT HERE]

Second, the locus of innovation differs between these two characteristics. Speed is largely determined by innovations in the laser engine. The speed with which a printer operates is a mechanical process that is constrained by the maximum speed of the laser engine. Although a laser printer producer

[6] Exceptions include Fujitsu and Ricoh, which are vertically integrated into printers and engines. Even these firms typically offer their engines for sale on the open market within a few months of introducing their own printers with such engines, thus enjoying only a very short period of internal-only use.

can slow down the speed of an engine through the code on the controller card, it is difficult for a printer to print faster than its designated engine speed. Thus, innovation in the PPM dimension is driven largely by engine manufacturers. In contrast, although resolution depends in part on the engine, it is primarily determined by the controller card. Notably, software techniques can raise the resolution of a printer through various mechanisms (e.g. offsetting the electrical charges by a half a step). Thus, innovation in resolution can be driven by the printer producer's research capability in achieving particular DPI ranges.

This has implications for the empirical testing of the hypotheses derived above. Since innovation by laser printer firms is centered around the software that supports particular levels of printer resolution, while innovation along the speed dimension is generally undertaken by laser engine suppliers and hence purchased through the market for engines, the firm-specific research capabilities of laser printer firms are thus likely to be specialized to particular DPIs. These capabilities can be combined with different engines to serve segments with different PPM requirements. To the extent that a laser printer firm seeks to enter classes where it can exploit its existing technological capabilities, such a firm is likely to enter new PPM classes within its existing DPI range. In contrast, entering new DPI classes within an existing PPM range offers fewer opportunities for a printer firm to exploit its firm-specific research capability.

[INSERT FIGURE 3 ABOUT HERE]

Figure 3 shows the pattern of class entry by HP and pioneering fringe firms. Three features stand out. First, in seven of these classes fringe firm entry precedes HP entry, which allows for comparison of competitive processes before and after HP's entry. Second, the initial dates of entry indicate that, over time, firms have pioneered increasingly high-resolution classes. In contrast, firms generally began in the center of PPM space and have moved into both higher- and lower-speed classes, suggesting a "dual frontier" of innovation (de Figueiredo & Kyle 2006). The variation in pioneering dates of classes raises the possibility that exogenous factors, such as technological constraints, may have made some classes infeasible for entry in early years of the industry. In our statistical analyses below we deal with this by considering a class to be "at risk" of entry after it has been entered by at least one firm.[7]

Third, HP ultimately enters nine of the 24 segments. HP's entry is particularly prevalent in the

[7] Another concern could be that Canon, as the dominant supplier to this industry, might influence segment entry and sales patterns. Notably, if Canon were to sell printers only (or first) to HP, and Canon engines drive customer demand, then the association between HP's entry and the sales takeoff could be spurious. To assuage this concern, we note that Canon engines appear in at least one model in every segment of the industry. Also, in every segment that HP enters, at least one fringe firm that preceded HP into that segment used Canon engines before HP's entry.

lower-resolution segments. HP also appears to "skip" segments in PPM space. For example, HP competes in classes 1, 9 and 21, but chooses not to enter class 5 (which is adjacent to 1 and 9 in PPM space) or 13 or 17 (which are adjacent to 9 and 21, respectively). Thus, rather than extending its product line to the most proximate segment, where one might expect its existing advantages to be most leverageable, HP chooses to locate further away.[8] We explore this statistically below.

IV. Empirical Analysis

We compiled life histories of each product and firm in the desktop laser printer industry, from its inception in 1984 through 1996. Our primary data source was Dataquest's annual *SpecCheck* report on page printers, which is the single most comprehensive public database on these printers. *SpecCheck* provides information on a variety of printer characteristics including manufacturer, initial ship date, speed in PPM, resolution in DPI, and other features. To fill in missing data from early years in the industry, we supplemented this data source with information from *PC Magazine* and *PC World*. In addition, we obtained price and quantity data from a separate, non-public Dataquest market research database and from a private consulting firm that had engaged in a long-term study of this industry. We believe that the resulting dataset is the most comprehensive available. Over the 13-year period, we record 3,836 printer-year observations that aggregate up to 1,882 firm-class-year observations.

To test our hypotheses, we analyze entry into and exit from product classes, both at the firm- and the class-level. We also analyze the effect of dominant firm entry on price and sales unit volume. Consequently, we construct five distinct dependent variables to support these analyses.

$\underline{\text{Entry}}_{ijt}$ is a categorical variable set equal to 1 if firm *i* enters class *j* in year *t*, and 0 otherwise. Firm *i* enters class *j* when it introduces its first product into that class. Subsequent introductions by firm *i* of additional products into that class are not considered entries.

$\underline{\text{EntryCount}}_{jt}$ is a count of the number of firms that enter class *j* in year *t*.

$\underline{\text{Price}}_{kjt}$ is measured as the price charged for printer *k* produced by firm i in class *j* in year *t*. We report models using the list price because the list price data are significantly more complete than the street price data. Results using the street price data are substantively the same.

[8] Ultimately, however, HP faces a tradeoff between staying in its existing resolution range and avoiding adjacent segments. At this point (1992-1993), HP begins to locate in neighboring segments rather than move to a new resolution range, although HP's final entry in 1996 is to a non-adjacent segments in a new resolution range.

UnitSales$_{jt}$ is measured as the natural log of the number of printer units sold (plus 1) in class *j* in year *t*. Unit sales data, by printer model, is aggregated at the class-year level.

Exit$_{ijt}$ is a categorical variable set equal to 1 if firm *i* exits class *j* in year *t*, and 0 otherwise. Firm *i* exits class *j* when it ceases to ship any product in that class. If firm *i* withdraws one or more products from class *j*, but continues to sell at least one other product in that class, it does not exit the class.

We employ a variety of independent variables that measure the sales growth in classes, the degree of competition in the focal class, the number of classes in which the focal firm participates, timing of entry of the focal firm, timing of HP's entry (interacted with other variables), and several of clocks that measure elapsed time from a relevant event. These variables are defined in Table 1. Descriptive statistics can be found in Table E1 of the electronic appendix. The mean Price charged for a printer between 1984 and 1996 is $4,240. The mean UnitSales for a class during this time period is roughly 117,000 units/year. However, unit sales vary tremendously from 0 in some class-years to more than 1,000,000 in others.

[INSERT TABLE 1 ABOUT HERE]

To test our firm-level hypotheses about entry and exit, we estimate piecewise hazard rate models of the probability of a firm entering or exiting a given class.[9] To test our class-level hypotheses about entry, where the dependent variable is a count, we estimate negative binomial models. Finally, to test our hypotheses about price and sales, where the dependent variables are continuous, we estimate OLS models with class random effects. The results presented here are largely robust if we expand our definition of dominant firm to include firms that have 10% market share in a given year.

Results

Entry

Table 2 presents results of our tests of Hypotheses 1-3, concerning the timing and direction of entry into new classes by dominant and fringe firms in the laser printer industry. To examine whether Hypothesis 1 is valid, we examine how a change in quantity sold in a dominant firm's existing segment affects the probability the firm will enter a new segment. To test Hypothesis 2, we explore whether firms that enter new segments pursue segments in the same DPI range as their existing segments, thus exploiting their current DPI capabilities. Finally, to test Hypotheses 3a and 3b, we examine whether

[9] We thank Glenn Carroll for advising us on this approach. The full analysis and convergence to five pieces is available from the authors. The results are robust to alternate hazard-rate specifications.

dominant and fringe firms skip neighboring segments when they choose new segments to enter. To gain initial traction on these hypotheses, we look at the descriptive data. Figure 4 provides descriptive evidence on what motivates the dominant firm to enter new markets. The flattening or decline of sales in classes where HP participates seems to precipitate new entry by HP. Combining this with Figure 3, there appear to be three patterns in the data: a) HP enters a new segment when it experiences a slowdown in sales growth in existing segments; b) HP extends its product line along the DPI dimension, and c) HP seems to avoid adjacent segments until it can no longer do so while staying in the same DPI range. These patterns are consistent with Hypotheses 1, 2, 3a, and 3b. Although the figures are useful evidence for the theory, Table 2 presents a hazard rate estimation to more rigorously test these hypotheses.

[INSERT TABLE 2 AND FIGURE 4 ABOUT HERE]

Model 1 provides a baseline piecewise exponential hazard rate model with robust standard errors clustered on the firm.[10] Model 2 introduces the independent variable SalesGrowthInCurrentClasses. Models 3 through 5 introduce additional firm variables and HP-related variables. Since a likelihood-ratio test indicates that Model 5's explanatory power is greater than that of preceding models, and since the magnitudes of the coefficients across these models are relatively stable, we direct our attention to Model 5.

The focal variables to test Hypothesis 1 are the direct and interactive effects of SalesGrowthinCurrentClasses and HP*SalesGrowthinCurrentClasses. The coefficient on the main effect is slightly negative and does not meet the traditional standards of statistical significance. This suggests fringe firms are not motivated to enter new classes when sales growth in their existing classes declines. However, the coefficient on the interaction term, HP*SalesGrowthInCurrentClasses, is large (in absolute value), statistically significant, and negatively related to entry into a new class. This result is consistent with Hypothesis 1; after controlling for a range of firm, class, and industry characteristics, the dominant firm is more likely to enter a new class as sales growth in its existing classes falls.

To test Hypothesis 2, we examine the variables SameDPI and HP*SameDPI. These variables measure the extent to which a firm enters new product segments which are in the same DPI range as its current products. Recall that Hypothesis 2 applied to all firms seeking new markets. The coefficient on SameDPI is positive, with the underlying hazard ratio indicating that a firm is 2.4% more likely to pursue entry into segments within its current DPI ranges than in other DPI ranges. In Model 5 the coefficient on

[10] We present the exponentiated coefficients from the hazard-rate estimation rather than the hazard ratio for clarity.

HP*SameDPI is not statistically different from zero.[11] As expected, HP shows no greater tendency to follow its innovation trajectory in DPI space than fringe firms. However, the coefficients for SamePPM and HP*SamePPM exhibit the same patterns of sign, magnitude, and significance. Since our operationalization of Hypothesis 2 anticipated that firms would not only be likely to enter segments in the same DPI range but also more likely to enter these segments than those in the same PPM range, we interpret the above as only weak evidence in support of this hypothesis.

Our examination of Hypothesis 3 focuses on the coefficients of Neighbor and HP*Neighbor. The coefficient on Neighbor is large, positive, and statistically significant. A fringe firm is 104% more likely to enter an adjacent market segment than a segment further away. Consistent with H3a, fringe firms choose to enter adjacent markets, presumably to take full advantage of opportunites to exploit existing technological assets and/or scope economies. However, HP does not follow this strategy; in fact, the coefficient on HP*Neighbor suggests it follows the opposite strategy. It is 71% less likely than other firms to enter adjacent segments than segments further away. Measuring the direct and interactive effect together, the model demonstrates that HP is 41% less likely to pursue adjacent segments than more distant ones. This is consistent with Hypothesis 3b, which suggests the dominant firm will avoid adjacent segments to avoid cannibalization of its current product portfolio.

The remaining results from Table 2 also point to several other factors influencing a firm's entry decision. Consistent with prior research, we find that density in a class has an inverted-U relationship with the hazard of entry into that class. We also find that industry age and class age each have a negative relationship with entry.[12] FirmAge has a positive coefficient, indicating that older firms are more likely to diversify into new segments, while the current sales growth in a focal segment (SalesGrowthInClass) has little relationship with the probability of entry into that segment.

Effect of Dominant Firm Entry on Price and Sales

Hypotheses 4 and 5 predict that individual segments will experience an accelerated price decline and sales take-off because of the dominant firm's entry. First we examine the price trends with descriptive data. Figure 5 presents the price trends in a representative class, both for HP and for fringe firms, and before HP and after HP. Note that there seems to be a declining trend in price over time. HP's entry,

[11] In Model 4, this coefficient is statistically significant and negative, but this effect goes away once we control for entry into neighboring classes. This underscores HP's aversion to entering adjacent classes.
[12] When we include IndustryClockSq and ClassClockSq, all of the clocks are significant. No other coefficients change in sign, magnitude, or significance.

however, is associated with a step-function decrease in the price. (Graphs for all segments, available from the authors, show patterns that largely conform to Figure 5.) Table 3 presents the results of a statistical test of these patterns. Model 1 provides a baseline OLS estimation with class random effects. Model 2 adds ClassDensity; the addition of this variable does not improve the fit of the model.[13] Model 3 adds HPInClass and HPClock to identify the effect of the dominant firm's entry into the segment. Given the construction of these two variables (as described in Table 1), HPInClass captures the initial (shift) effect of HP's entry on segment price, while HPClock captures how prices change in the segment (slope) as HP stays in the segment. This model is a significant improvement over the first two.

ClassClock has a negative and statistically significant coefficient, indicating that the price of a laser printer in a class falls over time. This result is consistent with the general literature on technology goods witnessing price declines over time. Consistent with the prediction of Hypothesis 4, HPInClass has a negative coefficient that is statistically significant, indicating that HP's presence in a segment is associated with lower prices. The magnitude of this coefficient is roughly 2.5 times the magnitude of the ClassClock coefficient, meaning that the entry of HP into a segment is associated with a price drop that would take more than 2.5 years to occur in HP's absence.

HPClock has a positive and statistically significant coefficient that is roughly half the magnitude of ClassClock's coefficient (in absolute value terms). This indicates that price, after plummeting upon HP's entry, declines more gradually over time than it would in the absence of HP. Although there is little extant theory about the long-term effect of dominant firm entry on prices, this pattern of steep initial price drop and slower long-term rate of decline is consistent with some prior empirical research concerning entry by a low-cost player in the airline industry (Goolsbee and Syverson, 2005).[14] This one-time drop and subsequent lower rate of decline is also plausibly consistent with circumstances in which Cournot competition between high-cost firms is supplanted by Stackelberg competition between a high- and a low-cost firm, for sufficiently different levels of cost between high- and low-cost firm.[15]

Having obtained substantial traction on Hypothesis 4, we extend our analysis to examine HP's prices relative to other firms in the segment. In Model 4 we introduce two new variables, HPDum and

[13] ClassDensitySq is omitted because there is no theoretical rationale for a non-linear relationship between number of firms and price. Its inclusion does not change the reported results.
[14] Goolsbee and Syverson (2005) find that airfare prices on a route decline rapidly in anticipation of, and for one year after, entry by Southwest into the market. Prices then exhibit a lower rate of decline than had existed before the threat of Southwest entry existed.
[15] Analytical results demonstrating this are available from the authors.

HPDumClock, to determine whether HP's printers are priced differently than those of fringe firms. HPDum is statistically significant and negatively related to price, with a coefficient of nearly -1,500. HPDumClock is positively related to price, with a coefficient of 258. This implies that when HP first enters a segment, its printers are priced nearly $1,500 below the average printer in that segment. Over time, this price gap shrinks. This result is consistent with our broader theory and with the price graph in Figure 5; as the current fringe firms are replaced by new fringe firms that follow HP into the segment, we would expect the price differential between HP and the average fringe competitor to shrink.

[INSERT TABLES 3 and 4 AND FIGURES 5, 6, 7, and 8 ABOUT HERE]

We now turn to Hypothesis 5, which predicts that the dominant firm's entry into a class will create a substantial increase in sales in the class. Figure 6 illustrates that, as a single market, the desktop laser printer industry sales takeoff appears similar to that found in other industries (see, for example, Agarwal and Bayus 2002). Thus, results from this industry are not likely to be a result of an idiosyncratic nature of a sales takeoff. Figure 7 shows similar information for a single class, and also indicates the year of entry by HP. HP's entry appears to precede both the bulk of fringe firm entry and the takeoff in sales. (Graphs for all segments, available from the authors, show patterns that largely conform to Figure 7.) Thus, although this class appears to exhibit a pattern of entry and sales that is consistent with prior research on the sales takeoff, inclusion of information on HP's entry raises the possibility that both fringe firm entry and sales takeoff are triggered by dominant firm entry. To explore this further, Figure 8 describes the magnitude of the sales takeoff across each class. This table shows that classes that experience HP entry have much higher peak sales (always occurring after HP entry) than those that do not. Together, Figures 7 and 8 suggest that the existence and timing of sales takeoff coincides with the entry of the dominant firm. We explore this further through regression analysis in Table 4.

Model 1 in Table 4 provides a baseline OLS estimation with class random effects; Models 2-5 include additional variables. Since the coefficients are relatively stable across models and Model 5 offers the best fit, we focus on a discussion of that model. ClassClock has a positive coefficient and ClassClockSq has a negative coefficient, indicating that sales rise and then fall as a class ages, with the inflection point around 6.6 years. HPInClass has a positive, significant, and extremely large coefficient, while HPClock and HPClockSq are not significant. This indicates that HP's entry into a class is associated with an astounding 3,500% increase in sales, controlling for other factors. This dramatic increase in sales is consistent with descriptive data found in Figures 7 and 8 and also with Hypothesis 5.

The “Churn”

In our final two predictions, Hypotheses 6 and 7, we examine the churn in the segment created by the dominant firm’s entry. We predict that incumbent fringe firms will tend to exit the segment when the dominant firm enters, while another set of fringe firms will enter the segment and compete in the shadow of the dominant firm. Table 5 presents the results of a negative binomial estimation of entry by fringe firms into each class as a function of HP’s presence, among other characteristics. Although Models 1 through 4 provide non-nested specifications, they generate coefficients that are remarkably similar across models. We therefore focus our discussion on Model 4. In this model, HPInClass has a positive and statistically significant coefficient. After controlling for basic industry and class characteristics, HP’s presence in a class is positively associated with fringe firm entry into that class, as predicted by Hypothesis 6. In addition, consistent with prior research, we find that ClassDensity and ClassDensitySq exhibit positive and negative associations, respectively, with entry into a class.

[INSERT TABLES 5 AND 6 ABOUT HERE]

Finally, we examine the effect of dominant firm entry on fringe firm exit. Hypothesis 7 predicts that after a dominant firm enters a segment, fringe firms that preceded it into the segment will be more likely to exit than fringe firms that follow it into the segment, *ceteris paribus*. Table 6 presents the results of a piecewise exponential hazard rate model with robust standard errors clustered on the firm to test this prediction. Model 1 provides a standard baseline model. IndustryClock is negatively related to exit while ClassClock is positively related to exit. This suggests that exit rates from an industry decline over time, but firms accelerate their exit from old classes as new classes open up (or as the dominant firm expands into additional segments). Surprisingly, the density of firms in a class exhibits an inverted-U relationship with exit, which is contrary to the conventional result in population-wide studies. However, firm age exhibits an inverted-U relationship with exit, consistent with a liability of adolescence that has also been found in prior literature. Other factors do not have a significant effect on fringe firm exit.

Model 2 adds HPPreceder_{ij}, which identifies firms that precede HP into a class. HPPreceder has a significant and positive coefficient, indicating that firms that precede HP into a class have a 107% higher rate of exit than firms that follow HP. Note, however, that this variable does not vary with time; hence, it does not distinguish between time periods before the entry of HP and time periods after its entry. We turn to the heart of the question in Model 3 where we replace HPPreceder with two time-varying variables, $\text{HPPrecederBeforeHPEntry}_{ijt}$ and $\text{HPPrecederAfterHPEntry}_{ijt}$. These variables permit us to observe the effect of HP's entry on fringe firms that precede it into a class, and to compare before/after exit rates to each other as well as to the unobserved category of fringe firms that follow HP into a class. HPPrecederBeforeHPEntry has a positive coefficient, but it is not significant. Exit rates for fringe firms in a segment that HP has not yet entered are statistically indistinguishable from those for fringe firms that follow HP into a segment. In contrast, HPPrecederAfterHPEntry has a positive, significant coefficient of substantial magnitude; after HP enters a segment, fringe firms that preceded it are 128% more likely to exit than fringe firms that followed it, after controlling for firm age and key class and industry characteristics. This is consistent with the exit prediction of Hypothesis 7—incumbent fringe firms will exit after the entry of the dominant firm, while firms that enter with or after the dominant firm will be less likely to exit, *ceteris paribus*. Indeed, the combination of Hypothesis 6 and 7 generate churn in the industry.

Alternative hypotheses

Our theory proposes that the dominant firm can create changes in both the supply curve and demand curve which in turn creates a wave of entry (and exit) by fringe firms, a price decline, and a sales takeoff. There are four alternative hypotheses that might explain the same results. First, it could be that the sales takeoff is generated solely by the dominant firm shifting the supply curve but having no effect on the demand curve. Second, it could be that the fringe firms that enter contemporaneously with the dominant firm cause these effects; the dominant firm entry is merely correlated with these effects. Third, it could be that the sales takeoff is caused by exogenous factors, and that the dominant firm is a particularly good forecaster of which segments will experience a takeoff. Fourth, technological change could enable provision of printers at low cost at a point in time, and this triggers entry by a swarm of firms (including HP) as well as the price decline and sales takeoff; this could be particularly pronounced if the demand curve is highly inelastic at high prices and is highly elastic at lower prices.[16]

Although we can not conclusively rule out all of these alternative hypotheses, we believe that the preponderance of evidence as found in our data and analysis supports our explanation for the laser printer industry.[17] We base our interpretation primarily on six facts. First, HP often enters classes that are adjacent to, and more technologically challenging than, classes that it skips (e.g., segment 18 vs. segment

[16] We thank an anonymous referee for suggesting the fourth alternative explanation.
[17] We address these at greater length in the Electronic Appendix. Note, this discussion applies to the printer industry and might not apply to other industries.

14). Second, fringe firms that precede HP into a class tend to exit after HP enters. Third, HP entry into a new segment is triggered by slowing growth in HP's existing classes. Fourth, Table 5 indicates that after controlling for HP, ClassDensity has no significant association with sales. Fifth, the sheer size of the sales takeoff is immense – 35x according to our estimation. Sixth, Figure 5 shows that fringe firms that follow HP price substantially below those that precede HP.

The first two facts work against the fourth alternative explanation. If technology has advanced sufficiently to support low-cost production in class 18, then it should also support low-cost production in the similar-but-less-complex class 14. Yet we do not see a wave of entry into that class in the absence of HP, and peak sales in class 18 exceed those of class 14 by a factor of five. It is difficult to reconcile this with an exogenous-technology explanation. Further, if this is explained by exogenous technological change, it is difficult to see why incumbent fringe firms should exit as the takeoff occurs. As far as the good-forecaster explanation, the third fact suggests that for this to be correct there would have to be systematic negative correlation between a sales takeoff in a new segment and a decline in sales in the existing segments – in other words, each time HP experiences a decline in existing segments, another segment is about to take off. While this is theoretically possible, it is empirically unlikely.

Fact four suggests that the sales takeoff is not driven by the fringe firms that enter with HP. ClassDensity is positively associated with increased sales when variables for HP's entry are omitted, but its coefficient become insignificant when the model includes HP variables. This implies that it is HP's presence in a class, and not the number of fringe firms, that sparks the sales takeoff. As for the possibility that the sales takeoff is entirely driven by a shift in the supply curve, we invoke facts five and six. Fringe followers price well below fringe preceders, implying that they are lower-cost producers. If HP's entry merely shifts the supply curve down, then it is not clear why fringe followers wait for HP to enter – a low-cost fringe firm could enter on its own and reap the resulting benefits. Further, the sales increase is of such magnitude that a shift in supply curve without a shift in demand (or change in demand elasticity) could only generate such an increase if the demand curve were already extraordinarily elastic.

V. Conclusion

This paper has sought to open a conversation on the dynamic processes by which a segmented industry evolves. To date, work on industry evolution has generally not dealt with this question. We propose that a dominant firm, faced with slowing growth in its current segment, will search for new segments in which to employ its resources. The new segments it chooses allow it to exploit its technological capabilities, but avoid cannibalization of its product line. The low-cost dominant firm will introduce lower prices (and likely alter demand through its other assets such as brand image), which will, in turn, trigger a sales take-off. Incumbent fringe firms that are well-suited to compete in the absence of the dominant firm will exit the segment; new fringe firms who are well-suited to compete in the shadow of the fringe firm will enter with or after the dominant firm. Thus, the entry of the dominant firm causes churn in the segment. As the market matures and growth slows in the segment, the process repeats itself.

Evidence from the desktop laser printer industry largely conforms to the predictions of this theory. Overall, we find that six of our seven theoretical predictions enjoy both descriptive and statistical corroboration, while one prediction finds some positive but weaker evidence. We believe that on the whole, this is a good outing and adds credibility to the idea that the theoretical insights of industry evolution can be extended to a segmented industry by incorporating theories of dominant firms that change industry structure and create churn.

That said, in this initial exploration we raise nearly as many questions as we answer. Several are particularly relevant as areas for future research in dynamics, particularly in the dynamics of segmented industries. First, is the dominant firm equivalent to a collection of fringe firms, or is it qualitatively distinct? Although we present evidence that suggests dominant firms are different, it is possible that the entry of a group of low-cost fringe firms into a segment could achieve the same results as the entry of a dominant firm. Further exploration of this issue can help us understand the extent to which the evolution of segment industries must involve integration of insights from the dominant firm literature.

Second, what characteristics of fringe firms are associated with preceding HP into a segment (and then exiting upon HP's entry), vs. following HP? Further exploration of this can help us better understand the distinct patterns of fringe firm entry and exit evident in this study, and can more broadly help us to understand competitive interactions among fringe firms.

Finally, this study suggests two avenues of further research that draw on other literatures. Our empirical testbed has had a single dominant firm throughout our sample period. This enabled us to cleanly identify the behavior of this dominant firm and its effect on segmented markets. However, in many industries the dominant firm changes over time as one firm eclipses another (Henderson and Clark 1990, Christensen 1997). Such competition for a dominant position will likely have an impact on the entry and pricing behavior of these firms. Integrating work on the dynamics of innovation with the industry evolution in a segmented industry will likely be a productive avenue for future research to pursue. Relatedly, previous work has found entry rates and exit rates to be highly correlated (e.g., Dunne, Roberts and Samuelson 1988). Yet other literatures note an asymmetry around industry “shocks” whereby firms that precede the shock exhibit different exit rates than firms that enter after the shock (Nickerson & Silverman 2003; Utterback and Suarez, 1995). We find both correlation between entry and exit rates post-HP entry, and also an asymmetry between who exits and enters. Elucidation of these patterns in more depth is likely to be a fruitful endeavor for scholars to pursue.

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Table 1: Definition of Independent Variables and Summary of Predictions

Variable	Definition	Prediction
Industry-level variables		
IndustryClock_t	Age of industry at time t, set equal to t – 1984	
IndustryDensity_t	Number of firms in industry at time t	
$\text{IndustryDensitySq}_t$	$\underline{\text{IndustryDensity}_t}$ squared	
$\text{NumSegmentsOpened}_t$	# of segments that have had at least one entry at time t	
Class-level variables		
ClassClock_{jt}	Age of class j at time t, set equal to t – year that class had first entrant	
ClassDensity_{jt}	Number of firms in class j at time t	
$\text{ClassDensitySq}_{jt}$	$\underline{\text{ClassDensity}_{jt}}$ squared	
SalesGrowth_{jt}	Unit sales in class j at time t minus unit sales in class j at time (t-1), divided by unit sales in class j at time (t-1)	
HPInClass_{jt}	1 if HP competes in class j in year t, and 0 otherwise	H4: negative in price model H5: positive in sales model H6: positive in entry count model
HPClock_{jt}	HP's tenure in class j at time t, set equal to t – year that HP entered class j	
Firm-level variables		
FirmAge_{it}	Age of firm at time t, set equal to t – year that firm i first entered industry	
FirmAgeSq_{it}	$\underline{\text{FirmAge}_{it}}$ squared	
$\text{SalesGrowthInCurrentClasses}_{it}$	Sum of unit sales across all classes in which firm i competes at time t minus sum of unit sales across same classes at time (t-1), divided by sum of unit sales across same classes at time (t-1)	
NumClasses_{it}	# of classes that firm i competes in at time t	
HPDum_i	1 if firm i is HP and 0 otherwise	
Firm-class-level variables		
SameDPI_{ijt}	1 if, at time t, firm i already competes in at least one class that is in the same DPI row as class j; 0 otherwise	H2: positive in entry model
SamePPM_{ijt}	1 if, at time t, firm i already competes in at least one class that is in the same PPM column as class j; 0 otherwise	
Neighbor_{ijt}	1 if, at time t, firm i already competes in at least one class that is directly adjacent to class j; 0 otherwise	H3a: positive in entry model
HPPreceder_{ij}	1 if firm i entered class j before HP has entered class j (NB: if HP has not entered class j by 1996 then this is 1 for all firms in class j); 0 otherwise	
$\text{HPPrecederBeforeHPEntry}_{ijt}$	1 if firm i entered class j before HP has entered class j <u>AND</u> HP has not yet entered class j as of time t	
$\text{HPPrecederAfterHPEntry}_{ijt}$	1 if firm i entered class j before HP has entered class j <u>AND</u> HP has entered class j as of time t	H7: positive in exit model
HP interaction variables		
$\text{HP*SalesGrowth}_{ijt}$	Interaction term between HPDum and SalesGrowth	
HP* $\text{SalesGrowthInCurrentClasses}_{it}$	Interaction term between HPDum and SalesGrowthInCurrentClasses	H1: negative in entry model
HP*SameDPI_{ijt}	Interaction term between HPDum and SameDPI	
HP*SamePPM_{ijt}	Interaction term between HPDum and SamePPM	
HP*Neighbor_{ijt}	Interaction term between HPDum and Neighbor	H3b: negative in entry model

Table 2: The Timing and Direction of Entry into a New Segment

Piece-wise exponential hazard-rate estimation with robust standard errors

Unit of observation: firm-class-year (* = p < .10; ** = p < .05; *** = p < .01)

	(1)	(2)	(3)	(4)	(5)
Time piece 1	-18.815 ***	-19.444 ***	-18.161 ***	-18.490 ***	-17.812 ***
	(0.454)	(0.456)	(0.484)	(0.453)	(0.440)
Time piece 2	-5.558 ***	-5.482 ***	-4.999 ***	-5.348 ***	-5.560 ***
	(1.266)	(1.270)	(1.323)	(1.312)	(1.261)
Time piece 3	-2.964 ***	-2.920 ***	-2.736 ***	-3.088 ***	-3.293 ***
	(0.481)	(0.482)	(0.485)	(0.465)	(0.465)
Time piece 4	-2.279 ***	-2.221 ***	-2.220 ***	-2.529 ***	-2.764 ***
	(0.525)	(0.528)	(0.559)	(0.533)	(0.533)
Time piece 5	-0.840	-0.847	-1.293 *	-1.500 **	-1.742 **
	(0.676)	(0.682)	(0.743)	(0.721)	(0.718)
IndustryClock	-0.309 ***	-0.308 ***	-0.433 ***	-0.379 ***	-0.352 ***
	(0.060)	(0.060)	(0.074)	(0.065)	(0.064)
ClassClock	-0.092 **	-0.090 **	-0.097 **	-0.151 ***	-0.171 ***
	(0.041)	(0.041)	(0.042)	(0.045)	(0.044)
SalesGrowthInClass	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ClassDensity	0.137 ***	0.136 ***	0.142 ***	0.111 ***	0.108 ***
	(0.032)	(0.032)	(0.033)	(0.032)	(0.032)
ClassDensitySq	-0.003 ***	-0.003 ***	-0.003 ***	-0.002 ***	-0.002 ***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
SalesGrowthInCurrentClasses		-0.021 *	-0.011	-0.025	-0.025
		(0.011)	(0.007)	(0.017)	(0.017)
Firm Age			0.294 ***	0.182 ***	0.183 ***
			(0.062)	(0.042)	(0.042)
SamePPM				0.661 ***	0.494 ***
				(0.122)	(0.148)
SameDPI				0.595 ***	0.505 ***
				(0.058)	(0.077)
Neighbor					0.498 **
					(0.225)
HPDum			0.466	1.212 ***	1.394 ***
			(0.302)	(0.256)	(0.243)
HP*SalesGrowthInClass			0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)
HP*SalesGrowthInCurrentClasses			-0.459 ***	-0.418 ***	-0.435 ***
			(0.060)	(0.058)	(0.059)
HP*SamePPM				-0.447 ***	-0.093
				(0.118)	(0.140)
HP*SameDPI				-0.353 ***	-0.089
				(0.059)	(0.084)
HP*Neighbor					-1.267 ***
					(0.242)
N [a]	11342	11342	11342	11342	11342
# failures	205	205	205	205	205
# of subjects (firm-classes)	2248	2248	2248	2248	2248
# of clusters in S.E.	120	120	120	120	120
Log pseudolikelihood	-513.43	-510.08	-470.52	-414.77	-411.10

[a] Includes all firm-class-years for which firm i was at risk of entering class j during year t. Once firm i enters class j, it is not at risk of entering again. Firm i is not at risk of entering a new class until it is competing in at least one segment in the industry. Thus, we exclude the pioneering entry of each firm into the industry.

Table 3: The Effect of Dominant Firm Entry on Price Within a Class

OLS regression estimation with random effects (Dependent variable: $Price_{kjt}$)

Unit of observation: model-class-year (* = p < .10; ** = p < .05; *** = p < .01)

	(1)	*(2)*	*(3)*	*(4)*
ClassClock	-371.16 ***	-360.21 ***	-466.33 ***	-463.78 ***
	(23.00)	(27.39)	(40.95)	(40.93)
ClassDensity		-6.79	12.82	11.12
		(9.11)	(10.37)	(10.38)
HPInClass			-1139.40 ***	-1026.87 ***
			(289.01)	(291.69)
HPClock			191.63 ***	176.08 ***
			(50.08)	(50.33)
HPDum				-1497.44 ***
				(541.20)
HPDum*HPClock				258.38 ***
				(94.24)
Constant	6232.70 ***	6255.04 ***	6715.87 ***	6721.13 **
	(555.37)	(567.80)	(594.81)	(595.45)
N	3210	3210	3210	3210
# groups	23	23	23	23
Random effects	class	class	class	class
Wald chi-square	260.43 ***	261.15 ***	288.47 ***	297.23 ***
R-sq	.04	.03	.03	.03

Table 4: The Effect of Dominant Firm Entry on Sales Within a Class

OLS regression estimation with random effects (Dependent variable: $UnitSales_{jt}$)

Unit of observation: class-year (* = p < .10; ** = p < .05; *** = p < .01)

	(1)	*(2)*	*(3)*	*(4)*
ClassClock	0.767 **	2.923 ***	2.686 ***	2.806 ***
	(0.342)	(0.573)	(0.591)	(0.504)
ClassClockSq		-0.197 ***	-0.193 ***	-0.205 ***
		(0.080)	(0.082)	(0.078)
ClassDensity	0.121 **	0.074 *	-0.004	0.002
	(0.051)	(0.045)	(.046)	(.047)
HPInClass			3.312 **	3.889 **
			(1.494)	(2.017)
HPClock			0.093	-0.273
			(0.185)	(0.183)
HPClockSq				0.035
				(0.145)
Constant	3.766 ***	-0.371	-0.321	-0.515
	(1.503)	(1.410)	(1.389)	(1.379)
N	163	163	163	163
# groups	23	23	23	23
Random effects	class	class	class	class
Wald chi-square	61.14 ***	145.79 ***	180.80 ***	181.56 ***
R-sq	.26	.39	.49	.49

Table 5: The Effect of HP's Presence in a Class on Fringe Firm Entry

Negative binomial estimation with robust standard errors (Dependent variable: $EntryCount_{jt}$)

Unit of observation: class-year (* = p < .10; ** = p < .05; *** = p < .01)

	(1)	(2)	(3)	(4)
IndustryClock	-0.064	-0.089 **	-0.037	-0.074
	(0.063)	(0.043)	(0.060)	(0.057)
IndustryDensity	0.009		-0.015	-0.010
	(0.013)		(0.015)	(0.014)
IndustryDensitySq	-0.000		0.000	0.000
	(0.000)		(0.000)	(0.000)
ClassClock		-0.115	-0.127	-0.100
		(0.072)	(0.075)	(0.077)
ClassDensity		0.120 ***	0.126 ***	0.093 ***
		(0.027)	(0.031)	(0.030)
ClassDensitySq		-0.002 ***	-0.002 ***	-0.002 ***
		(0.001)	(0.001)	(0.001)
SalesGrowthInClass		0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
HPInClass				0.603 ***
				(0.156)
Constant	1.369 ***	1.469 ***	1.683 ***	1.652 **
	(0.311)	(0.339)	(0.312)	(0.349)
N	139	139	139	139
Log-pseudolikelihood	-290.75	-274.99	-274.08	-266.51
Wald chi-square	2.16	44.75 ***	55.50 ***	66.62 ***

Table 6: Effect of HP Entry on Fringe Firm Exit from Class **(“HP Preceders” vs. “HP Followers”)**

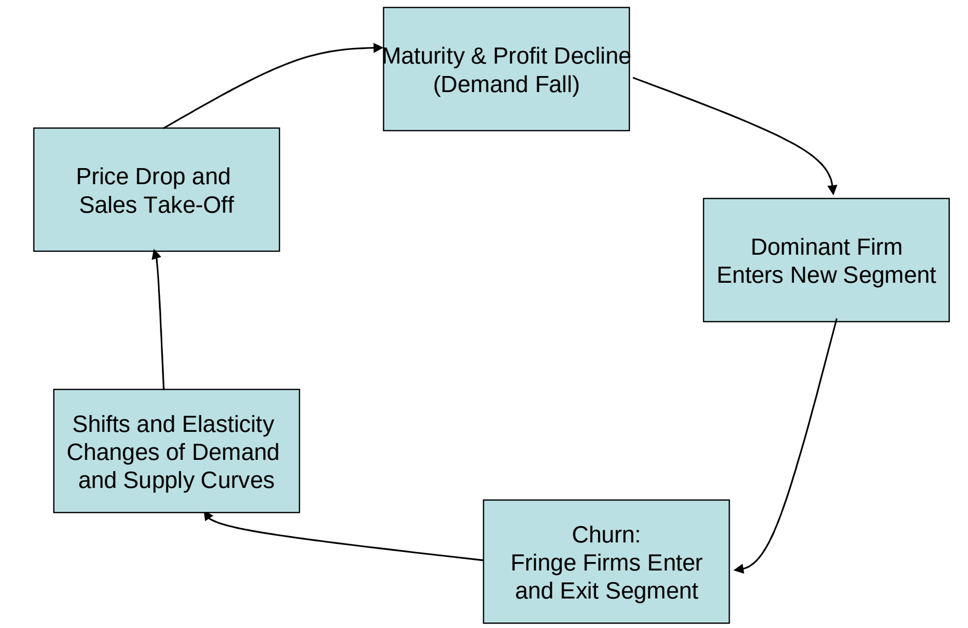
Piece-wise exponential hazard-rate estimation with robust standard errors

Unit of observation: firm-class-year (* = p < .10; ** = p < .05; *** = p < .01)

	(1)	(2)	(3)
Time piece 1	-7.279 ***	-7.805 ***	-7.597 ***
	(1.192)	(1.228)	(1.215)
Time piece 2	-3.401 ***	-3.842 ***	-3.631 ***
	(1.125)	(1.162)	(1.171)
IndustryClock	-0.431 ***	-0.426 ***	-0.439 ***
	(0.118)	(0.120)	(0.121)
ClassClock	0.301 ***	0.309 ***	0.320 ***
	(0.109)	(0.112)	(0.113)
SalesGrowthInClass	0.081 *	0.115 **	0.107 **
	(0.047)	(0.053)	(0.053)
ClassDensity	-0.001 *	-0.002 **	-0.002 **
	(0.000)	(0.001)	(0.001)
ClassDensitySq	-0.000	-0.001	-0.000
	(0.001)	(0.003)	(0.001)
FirmAge	0.607 ***	0.589 ***	0.575 ***
	(0.185)	(0.186)	(0.185)
FirmAgeSq	-0.057 ***	-0.056 ***	-0.055 ***
	(0.018)	(0.018)	(0.018)
NumClasses	0.031	0.031	0.030
	(0.078)	(0.074)	(0.073)
Neighbor	-0.129	-0.138	-0.139
	(0.294)	(0.297)	(0.298)
HPPreceder		0.730 **	
		(0.327)	
HPPrecederBeforeHPEntry			0.375
			(0.640)
HPPrecederAfterHPEntry			0.823 **
			(0.348)
N [a]	1931	1931	1931
# failures	65	65	65
# of subjects (firm-classes)	395	395	395
# of clusters in std errors	395	395	395
Wald chi-square	829.13 ***	795.77 ***	801.50 ***

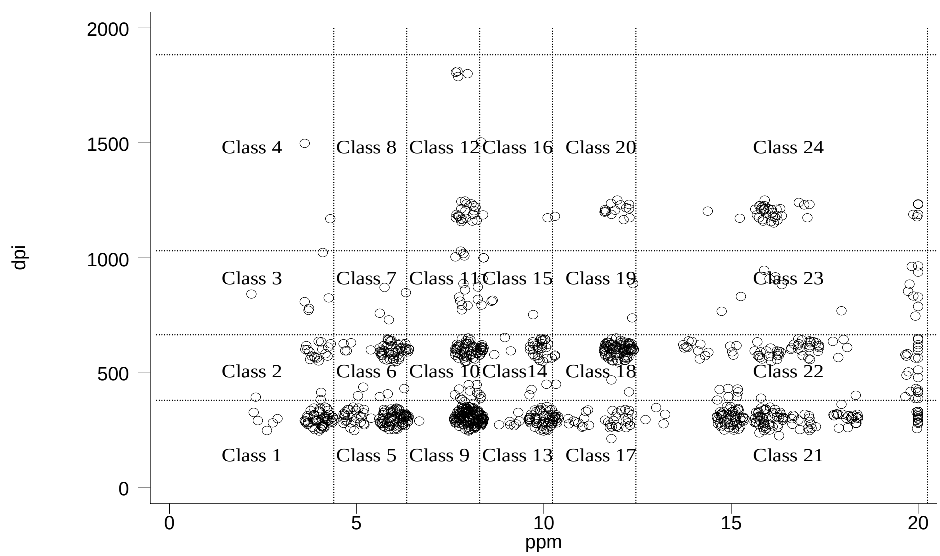
[a] Includes all firm-class-years for which firm i was at risk of exiting class j during year t. Includes all classes whether or not HP entered during the sample frame. For classes in which HP never enters, $HPPreceder_{ij} = 1$ and for all t $HPPrecederBeforeHPEntry_{ijt} = 1$. This assumes that these classes at similar risk of HP entry as those that experienced HP entry. We also estimate these models after restricting our sample to include only classes that HP entered during our sample frame. The results of these models, available from the authors, are qualitatively the same as those above.

Figure 1: Dynamic Cycle in Segmented Industry



Note: Neighboring Stages May Happen Contemporaneously

Figure 2: Product Distribution and Classes



Note: Each small circle represents a printer.

Figure 3: Entry into Laser Printer Product Classes

DPI

Class 4 1st entrant: 1993	Class 8 1st entrant: NA	Class 12 1st entrant: 1990	Class 16 1st entrant: 1995	Class 20 1st entrant: 1991	Class 24 1st entrant: 1994 HP enters: 1996
Class 3 1st entrant: 1991	Class 7 1st entrant: 1995	Class 11 1st entrant: 1988	Class 15 1st entrant: 1996	Class 19 1st entrant: 1992	Class 23 1st entrant: 1991
Class 2 1st entrant: 1990 HP enters: 1993	Class 6 1st entrant: 1987 HP enters: 1995	Class 10 1st entrant: 1990 HP enters: 1992	Class 14 1st entrant: 1988	Class 18 1st entrant: 1989 HP enters: 1992	Class 22 1st entrant: 1987 HP enters: 1993
Class 1 1st entrant: 1989 HP enters: 1989	Class 5 1st entrant: 1987	Class 9 1st entrant: 1984 HP enters: 1984	Class 13 1st entrant: 1986	Class 17 1st entrant: 1986	Class 21 1st entrant: 1986 HP enters: 1989

PPM

1

Figure 4: HP Printer Units Shipped by Year and Class
(Data not collected prior to 1987)

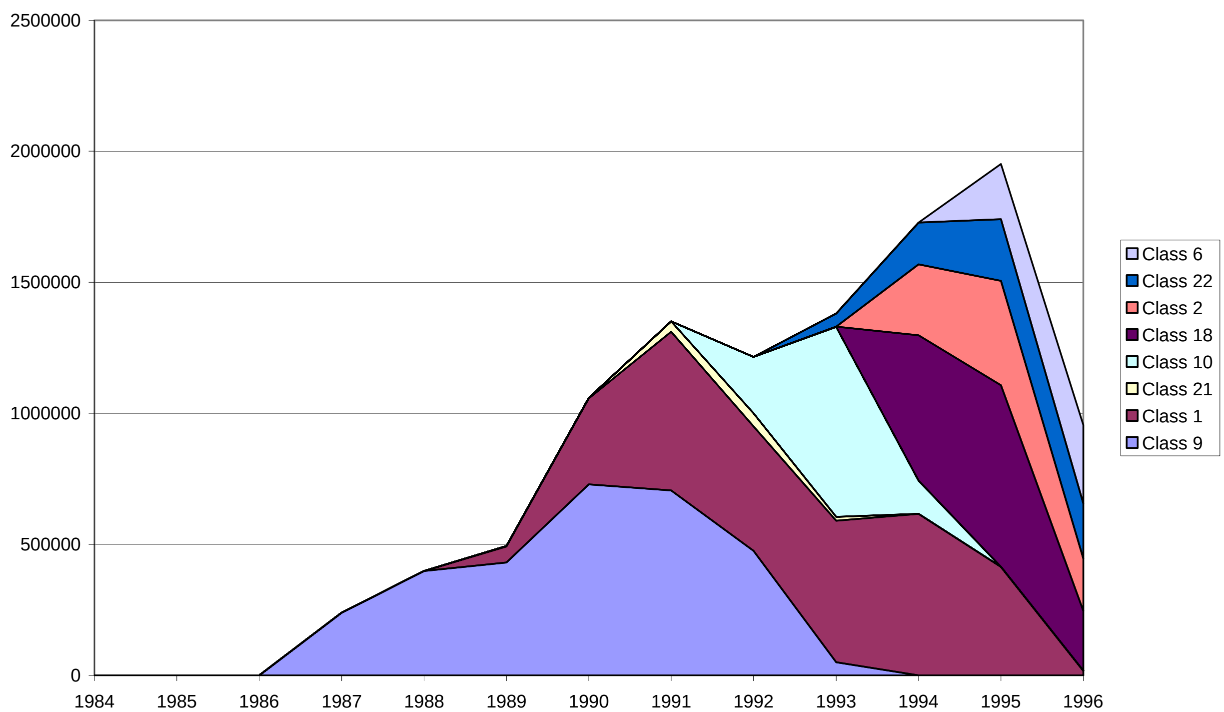


Figure 5:
Price Evolution in Class 22 (HP enters 1993)

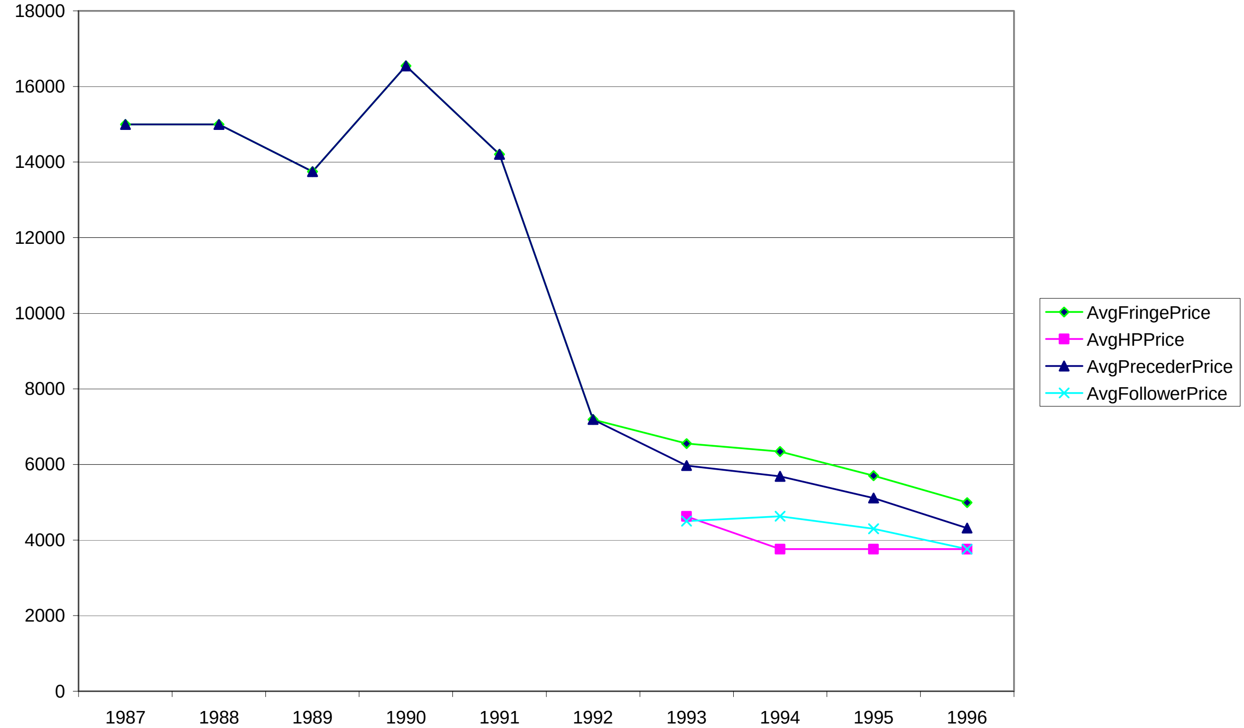


Figure 6: Firm Entry and Sales Take-Off in Laser Printer Industry
(Entire Industry: All Classes Combined)

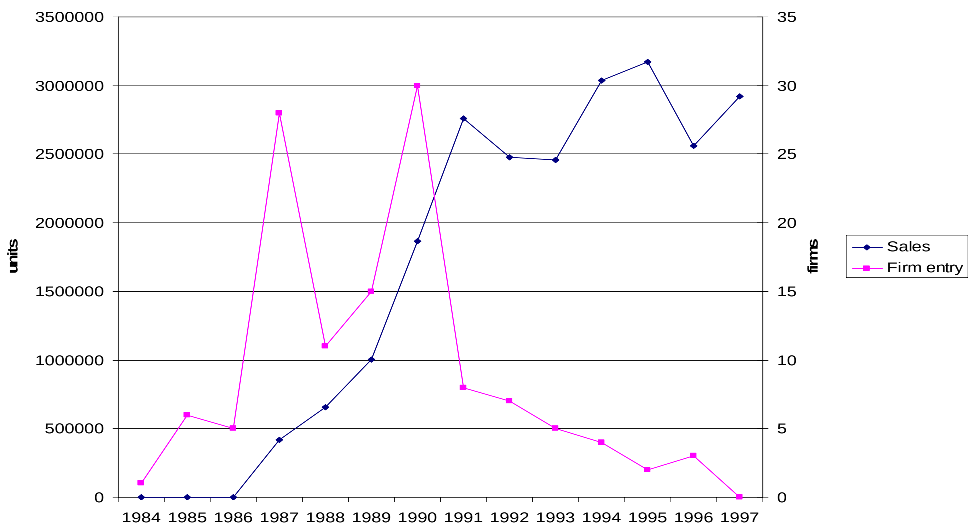


Figure 7:
Class 21 - Dominant Firm Entry, Fringe Firm Entry and Sales Takeoff (HP enters 1989)

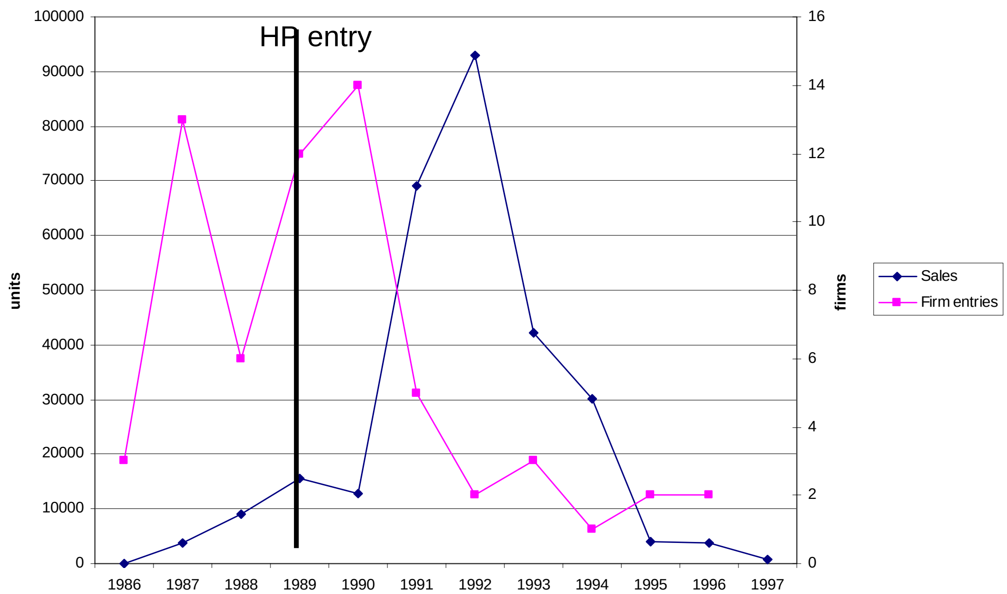


Figure 8
Peak Annual Sales by Class

Classes that HP enters,1984-1996				Classes that HP does not enter by 1996		
Class	*Peak Sales*	*Peak Year*	*Year of HP Entry*	*Class*	*Peak Sales*	**Peak Year**
9	1,038,626	1990	1984	5	396,054	1995
1	981,565	1991	1989	13	244,958	1991
18	789,467	1995	1992	14	127,300	1993
10	754,500	1993	1992	17	74,911	1991
6	518,829	1996	1995	7	25,650	1996
2	516,392	1995	1993	11	18,570	1996
22	254,579	1995	1993	20	9,610	1994
24	119,645	1996	1996	12	8,065	1995
21	93,054	1992	1989	23	< 5,000	1994
				19	< 5,000	1995
				3	< 5,000	1992
				4	< 5,000	1993
				15	< 5,000	1996
				16	< 5,000	1996

Churn, Baby, Churn:
Strategic Dynamics Among Dominant and Fringe Firms in a Segmented Industry

ELECTRONIC APPENDIX

The text of this electronic appendix examines potential effects of dominant firm entry on demand and supply, and evaluates the three alternative hypotheses identified in section IV of the paper. The purpose of this section is twofold. First, it examines the underlying economics of various patterns of entry, exit, pricing, and sales behavior in an evolving industry. It outlines what types of changes in demand and supply will yield what types of changes in pricing and sales. In doing this, it hopes to open up avenues for future research on industry evolution—guiding researchers to possible theoretical avenues to explore and integrate. Second, it applies this analysis to the data in the current paper on the desktop laser printer industry, and outlines what kinds of underlying economics could explain the data we observe in this paper. Note that although a subset of these mechanisms describe the behavior of our data, other mechanism could describe other industries. We hope that additional studies will be conducted explaining and extending these mechanisms and construct a theory of the underlying regularities of when these different mechanisms operate. In this sense, the Electronic Appendix outlines potential paths for future theoretical work to explore.

With respect to the first goal, this paper identifies four theoretically feasible changes sparked by the entry of the dominant firm in a given segment: 1) shift of the supply curve, 2) shift of the demand curve, 3) change of elasticity of the supply curve, and 4) change of elasticity of the demand curve. Here we discuss how these effects are likely to change to price and quantity sold in a market. It is important to note, however, that our theory is distinct from previous theories; while previous papers argue that changes to the structure of supply and demand are due to evolving technologies and the entry of numerous firms, we suggest that it is the *dominant firm* that creates these changes. Our study of the evolution of industry segments allows us to analyze the role of the dominant firm in creating these changes.

The literature generally finds the first of these is what drives a sales takeoff. Namely, as technology improves, low-cost entrants enter the industry; this results in a higher number of firms, lower prices, and a sales take-off. Figure E1 describes the initial and resultant effects of a supply shift. As can been seen from the figure, the initial price P* is higher than the final price P’, and the initial quantity sold Q* is lower than that the final quantity sold, Q’. This is the base case which has wide acceptance in the literature. (See for example, Bass 1980, Stoneman and Ireland 1983, Gort and Klepper 1982, Goldner and Tellis 1997).

Agarwal and Bayus (2002) have argued that the entry of fringe firms causes a supply shift *and* a demand shift—the second possible change noted above. In Figure E2, we consider what happens in when demand shifts out. As can be seen in Figure E2, Panel A, a demand shift can indeed result in a sales takeoff, but absent a supply shift it will also result in higher prices. This occurs because the demand shift raises everyone's willingness to pay. Figure E2, Panel B demonstrates the effect of demand shift accompanied with a supply shift, as argued by Agarwal and Bayus. The two shifts together causes an unambiguous, reinforcing increase in sales (moving from Q* to Q'). However, the effect on price is indeed ambiguous. The supply curve shift causes prices to fall, while the demand curve shift causes prices to rise. It is the net effect of these shifts that will determine whether actual prices will fall, stay the same, or rise, with the sales takeoff.

The third possibility is that entry of the dominant firm changes elasticity of the supply curve. It is hard to think about how this might occur, so we omit this case from our analysis in this paper.

The final case is that entry of a dominant firm can change the elasticity of demand, especially at the bottom end of the demand curve. This concept is new to this stream of literature, and the paper describes circumstances when this might occur. Figure E3, Panel A illustrates what a change in elasticity of low willingness-to-pay consumers might do the demand curve in a given segment. If only the lowest willingness-to-pay consumers are now willing to pay more with the entry of the dominant firm, there will be a rotation of the bottom part of the demand curve, below the current equilibrium price and quantity (P*, Q*). This means that if there is only a change in demand elasticity of the type described by the entry of the dominant firm into the segment, there will be no change in the equilibrium price and quantity.[1]

However, if the change in elasticity of the demand curve is accompanied by a shift in the supply curve, then we get both lower prices and a sales takeoff. This is illustrated in Figure E3, Panel B. The

[1] Note, also, that one could get a more elastic demand curve if individuals with high willingness to pay are now less willing to pay (say because the novelty or perceived innovativeness of the product is no longer valued). The IPOD is an example of exactly this effect. The IPOD is no longer considered "trendy", so that those with a formerly high willingness to pay have substantially lowered their current willingness to pay. On the other hand, middle-aged individuals, who were wary of the IPOD, are now willing to pay more for the product than they were earlier because the product is much more established. See David Smith, "Why the IPOD is Losing Its Cool," *The Observer*, September 10, 2006, http://observer.guardian.co.uk/uk_news/story/0,,1869042,00.html . We view this kind of outcome unlikely in a product like desktop laser printers.

demand elasticity change accelerates the sales takeoff caused by the supply shift, but it attenuates the price decrease caused by the supply shift. This can be seen by comparing P" and Q" (with both the supply shift and change in elasticity) to P' and Q' (only the supply shift). Nevertheless, provided the demand curve does not become backward bending, the change in elasticity accompanying the supply shift will also result in sales takeoff and a declining price for the product.

Using this theoretical discussion, we can now approach our second goal to analyze the behavior of firms in the laser printer industry. Note that this approach, while applied to the laser printer industry, is actually more general and could be used by future researchers as a basis for analyzing evolution in other segmented industries. We argue that the most plausible explanation for the observed patterns of entry, exit, price, and sales behavior in the laser printer industry relies on the dominant firm's entry causing a sales takeoff, in large part through a shift in the supply curve and change in elasticity of demand in the entered segment. We begin by noting from Tables 3 and 4, and the accompanying Figures 4 – 8, that prices decline and there is an enormous sales takeoff (35x) in the segments the dominant firm enters. This fact can be accounted for by all three outcomes: supply shift alone, supply shift plus demand shift, or supply shift plus change in demand elasticity. The supply shift argument, widely accepted in the literature, seems to hold here. The dominant firm, by virtue of its sales in the industry, is able to bring substantial economies of scale to the marketplace. Exploiting this scale, it is able to maintain a lower cost position in the market. This lower-cost position makes it optimally profit-maximizing to charge a lower price for its products.

The next step is to analyze whether demand is changing with the entry of the dominant firm. Recall that HP's entry into a segment is quickly followed by a swarm of fringe firm entry (Table 5). These fringe firms price below those fringe firms that preceded HP into the segment, and presumably these firms can survive at these prices. If the only effect of the dominant firm is to shift the supply curve outward while demand stays fixed, then it is not clear why these fringe firms should wait for the dominant firm to enter – rather, they should be able to enter the segment, lower prices, and generate the sales takeoff on their own. This suggests that the dominant firm's entry affects demand as well as supply.

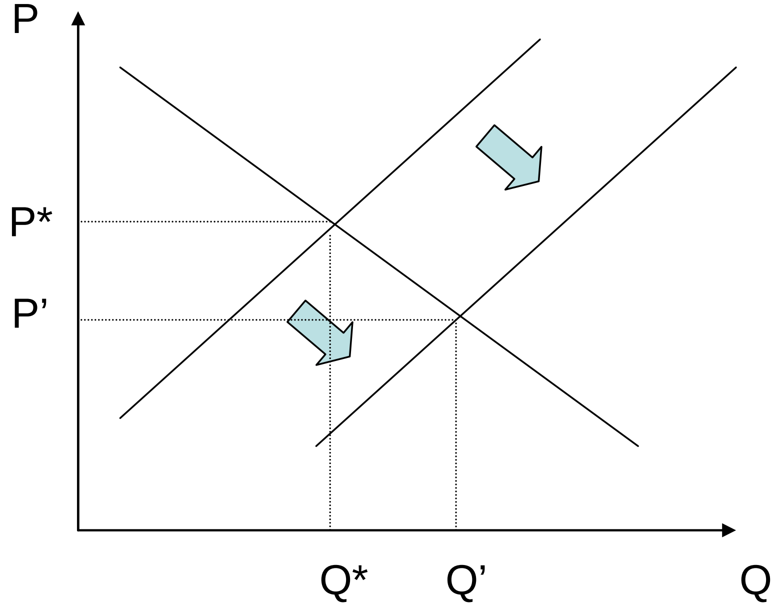
We now turn to the latter two possibilities—a shift in demand and a change in demand elasticity. A shift in demand would attenuate any price decline. Given the mean price of a printer of $4,240 (see Figure E4), Table 3 indicates that HP's entry is associated with a 25% price decline, the data show there is rarely a price increase after HP's entry. This result holds despite the fact that there is a 35x increase in quantity sold in the market (Table 4). Indeed, a demand shift would have to be enormous (unless the demand curve is already very elastic—almost flat) to generate quantity increases of this magnitude, which should result in a rise in prices in at least some cases. This rarely occurs. It is hard to take these two pieces of evidence and attribute them to a demand shift alone, without a change in elasticity of demand.

On the other hand, a supply curve shift coupled with a change in demand elasticity is not as hard to believe. First, unless the demand curve becomes backward bending, the two events cause an unambiguous decline in prices, as occurs in all segments in our data. Second, a flattening out of the demand curve is consistent with a small shift in the supply curve resulting in large changes in equilibrium quantity demanded. Third, as discussed in the paper, it is most likely those who are hesitant to enter a market (at the low end of the demand curve) that are likely to benefit most (and thus increase their willingness to pay) with the entry of a safe and secure dominant firm. Fourth, and quite importantly, it would be difficult for a fringe firm to replicate this change in demand elasticity. Having a fringe firm in the market does little to assuage customers that the segment has been legitimated, the product low risk, and the after-sales service quality will be high and persistent for a number of years. For these reasons, we believe that the evidence points to the dominant firm both shifting the supply curve (as is commonly believed in the literature) and changing the demand elasticity. A shift in demand is also possible; however, the evidence suggests that the combined effect of the supply shift and elasticity change exceed the demand shift.

While we interpret the evidence to indicate that it is the dominant firm's entry that causes this, it is still possible that the contemporaneous entry of fringe firms with the dominant firm is causing this sales takeoff. Indeed, Table 5 in the paper does demonstrate there is a wave of entry coincident with the dominant firm, possibly casting some doubt on the causal effect we argue in the paper. However, we provide three reasons why we believe that it is indeed the dominant firm causing this effect, and not the fringe firms. (Note that we have already demonstrated that the price decline and sales take-off occur when the dominant firm enters, so the purpose of this exercise is to provide reasons why we think this could *not* be the fringe firms causing this effect.) First, we have argued in the third and fourth points in the previous paragraph that the dominant firm brings with it characteristics which are unique that can cause this takeoff that fringe firms cannot replicate. Second, an examination of Figure 8 shows that there are almost no substantial sales takeoffs in the absence of the dominant firm in any segment. This would seem to be an unlikely pattern if the fringe firms could generate a sales takeoff by themselves. Third, results reported in Tables 3 and 4 suggest that the number of fringe firms in a segment does not influence the sales takeoff or price decline. Table 3 shows a statistically insignificant coefficient on the ClassDensity variable, indicating that the number of firms in a segment does not influence printer price after controlling for other factors. Table 4 shows a positive and significant coefficient for ClassDensity in the absence of HPInClass, but this coefficient becomes insignicant and is dramatically reduced in magnitude after including the HPInClass variable. This again suggests that the number of fringe firms in a segment does not affect sales in that segment once we control for the presence of the dominant firm. Thus, we conclude that the dominant firm is a prime motivator in the segment price declines and sales takeoff and that fringe firms follow the dominant firm in anticipation of the sales takeoff.

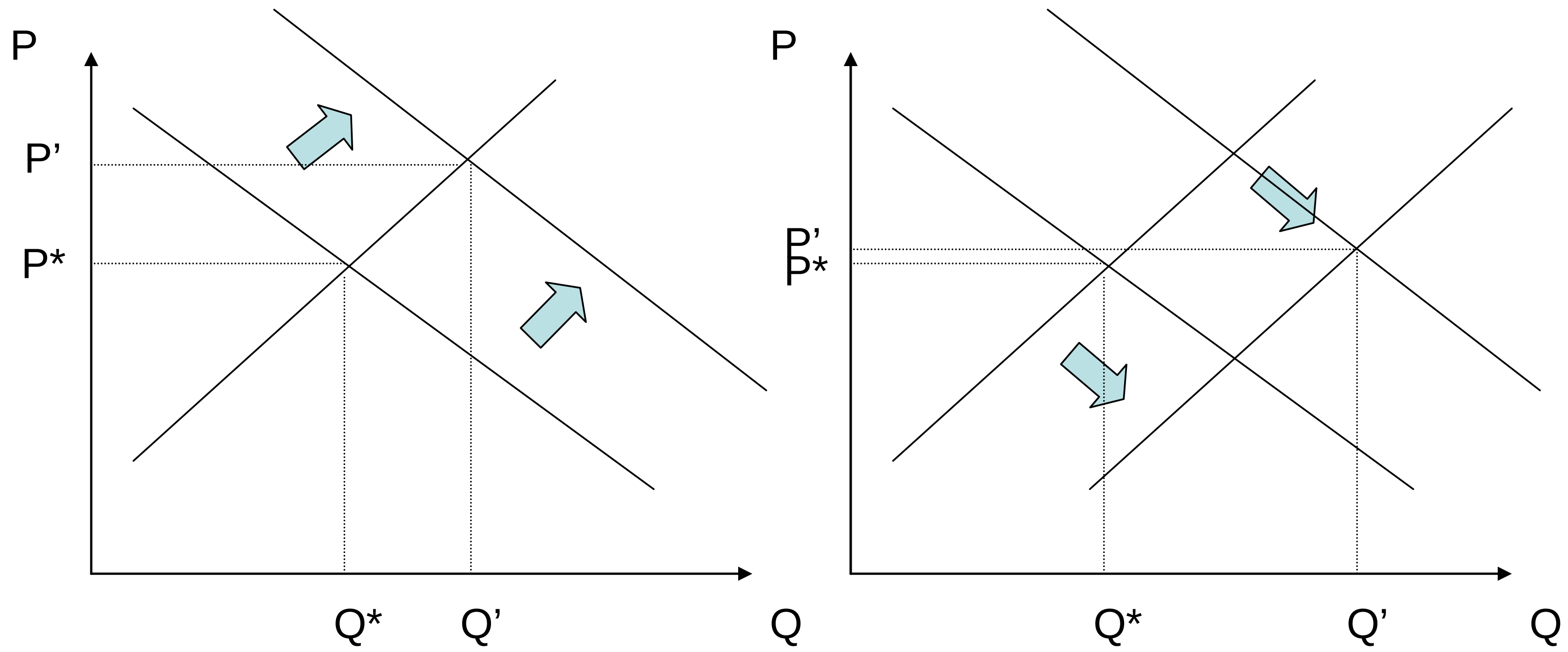
This brings us to a final discussion about the cause of the sales takeoff. Does the dominant firm create the sales takeoff or just forecast the takeoff better than other fringe firms? It is our belief that the dominant firm creates the sales takeoff. We have spent most of this appendix demonstrating reasons and evidence of the causal effect of the dominant firm. In addition, there is some evidence that it is not just forecasting. First, the dominant firm enters a segment when quantity sold declines in one of its incumbent segments. In order for forecasting to be the determinant of the sales takeoff, it would have to be true that *in every case* of quantity decline in an incumbent dominant firm segment, there is a sales takeoff in the new segment the dominant firm has entered. Moreover, declines in segments that the dominant firm does not compete in would have to negatively correlated with sales takeoffs (because the dominant firm would not switch segments). While this is a theoretical possibility, from an empirical standpoint, this is highly unlikely. Second, if one is to believe the forecasting story, it has to be the case that the dominant firm almost never forecasts incorrectly, as real sales takeoffs almost never occur in the absence of dominant firm entry. Again, while a theoretical possibility, it is empirically unlikely. Finally, if the dominant firm is merely forecasting the upcoming sales takeoff, it would not need to lower price when it enters a segment (or at least not lower it as much as it does). The sales takeoff would occur without a change in price. However, for all the same reasons that a shift in demand is unlikely, we believe that the price dynamics in the segments do not justify concluding that demand shifts exogenously or that forecasting is generating the result.

Figure E1
Base Case: Supply Shift



Supply Shift

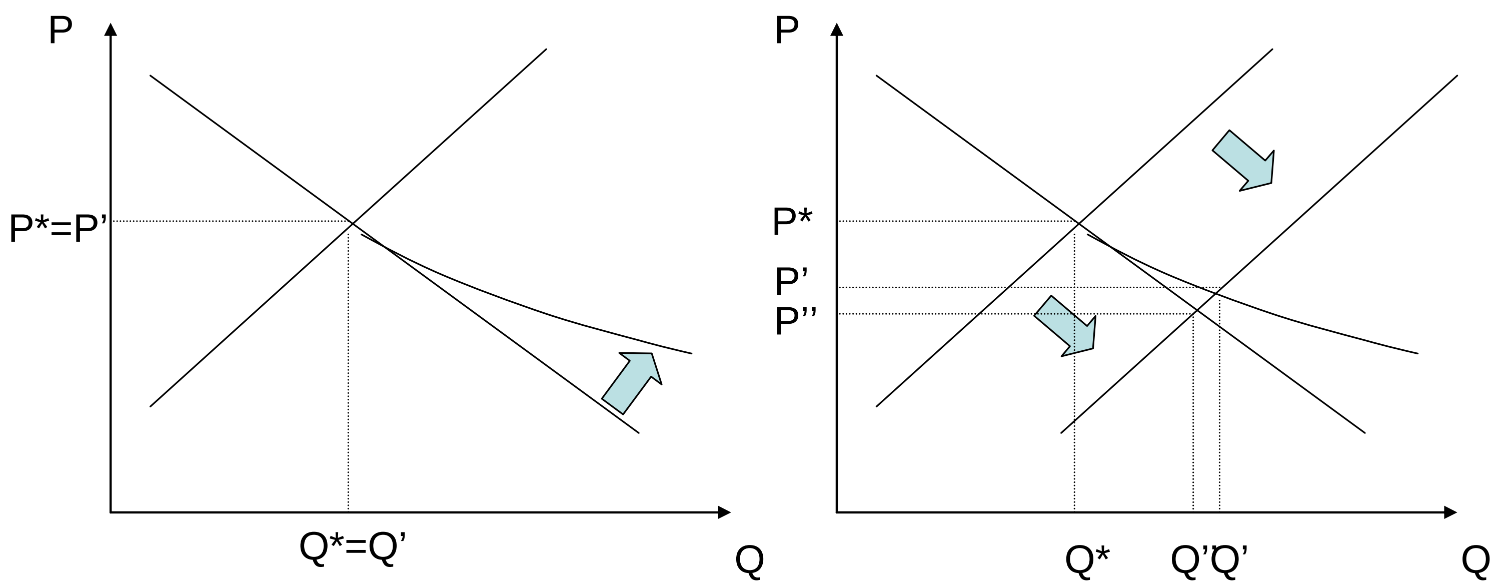
Figure E2
Demand Shift



Panel A: Demand Shift

Panel B: Demand and Supply Shift

Figure E3
Demand Elasticity Change



Demand Elasticity Change

Demand Elasticity Change
and Supply Shift

Table E1: Descriptive Statistics

Variable	Mean	Std.Dev	Min	Max
Dependent variables				
$Entry_{ijt}$	0.027	0.162	0	1
$Price_{kjt}$	4240.83	3695.45	219	35000
$UnitSales_{jt}$	7.912	4.756	0	13.853
$EntryCount_{jt}$	2.344	2.623	0	16
Independent variables				
$Exit_{ijt}$	0.040	0.195	0	1
$IndustryClock_{t}$	9.218	2.234	1	12
$IndustryDensity_{t}$	81.670	18.129	1	95
$NumSegsOpened_{t}$	17.561	3.971	1	22
$ClassClock_{jt}$	4.369	2.845	0	11
$ClassDensity_{jt}$	10.631	10.785	0	47
$SalesGrowth_{jt}$	47.041	294.280	-1	2174.721
$HPInClass_{jt}$	0.307	0.461	0	1
$HPClock_{jt}$	1.310	2.612	0	13
$FirmAge_{it}$	4.732	2.517	1	12
$SalesGrowthInCurrentClasses_{it}$	9.666	119.6	-1	2174.721
$NumClasses_{it}$	3.728	2.627	1	12
$HPDum_{i}$	0.010	0.103	0	1
$SameDPI_{ijt}$	0.764	2.361	0	1
$SamePPM_{ijt}$	0.206	1.118	0	1
$Neighbor_{ijt}$	0.233	0.423	0	1
$HPPreceder_{ij}$	0.213	0.409	0	1
$HPPrecederBeforeHPEntry_{ijt}$	0.078	0.268	0	1
$HPPrecederAfterHPEntry_{ijt}$	0.135	0.342	0	1
HP*SalesGrowth	0.456	28.87	-1	2174.721
HP*SalesGrowthInCurrentClasses	0.010	0.191	-0.91	4.961665
HP*SameDPI	0.037	0.629	0	1
HP*SamePPM	0.014	0.277	0	1
HP*Neighbor	0.005	0.071	0	1