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How Does Product Customization Affect Firm Survival?: The Role of Market Pioneering and Entry Deterrence

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Keywords: Product Customization, Submarket Pioneering, Entry Deterrence, Industry Evolution, Exploration-Exploitation

1. INTRODUCTION

Firm survival in an industry is generally linked to a firm's ability to mass-produce standardized goods. In this view, successful firms distinguished by their early adoption of a standard design undertake process innovation and mass production while others either fail to do so or worse continue to tinker with non-standard designs even after a standard has emerged (e.g., Suarez and Utterback, 1995). The survivors can leverage their production and distribution infrastructure and experience to enter emerging industries and navigate technological discontinuities successfully (Carroll et al., 1996; Tripsas, 1997; Klepper and Simons, 2000; Helfat and Lieberman, 2002). Inheriting knowledge about the production technology can also spur entrepreneurial entry among employees of the survivors (Agarwal et al., 2004; Klepper and Sleeper 2005). The organization of production can mirror organizational design and subtle improvements to the standard design can unseat survivors trapped in their optimal production routines (e.g., Henderson and Clark, 1990). This mass production view explains well the historical rise of several businesses and industries in the U.S. and several regularities concerning industry evolution (Chandler, 1962; Hounshell, 1984; Klepper, 1996).

Yet many other industries and particularly those producing intermediate inputs (producer goods) feature striking levels of product variety that belie their standardized industry classification (SIC) codes (e.g., Pine, 1993; Gilmore and Pine, 2000). For example, nine different flowmeter designs based on different principles of physics coexist within a four-digit SIC code while no standard design has emerged, limiting traditional advantages associated with mass production in that industry (Sutton, 1998). Examining such industries may be key to explaining irregularities in industry evolution such as why firms survive longer in some industries with a delayed shakeout and why established firms fail to respond to emerging customer needs (Klepper, 1997; Christensen and Bower, 1996; Chesbrough, 2003). In examining patterns of entry, exit, firm growth, and survival in such industries, recent research has developed analytical models of industry evolution featuring *submarkets* (e.g., Sutton, 1998; Klepper and Thompson, 2006). Firms in submarket industries face a trade-off between on the one hand product standardization and process innovation within a submarket and on the other submarket pioneering through product innovation (e.g., March, 1991; Levinthal and March, 1993; O'Reilly and Tushman, 2004). Prior research has emphasized a firm's experimentation, prototyping, and product customization activities in new product development (e.g., Eisenhardt and Tabrizi, 1997; Brown and Eisenhardt, 1997). The models of industry evolution featuring submarkets have thus far been silent on the origin of submarkets and assume their arrival and destruction to be random, exogenous, or associated with a cost parameter.

In a narrow sense, product customization involves providing attribute choices for functionally identical products such as offering automobiles in several paint colors to achieve greater market or customer orientation. It is in this limited sense that the existing literature on product customization takes up largely operations management issues in predominantly consumer goods industries (e.g., Day, 1994; Kotha, 1995; Lampel and Mintzberg, 1996; Gatignon and Xuereb, 1997; Dellaert and Stremersch, 2005). The limited theoretical literature in marketing on the subject focuses on strategies to extract greater surplus from product customization while treating the size of the market as fixed (e.g., Syam, Ruan, and Hess, 2005; Mendelson and Parlakturk, 2008). Yet product customization can lead to the discovery of new submarkets with functionally differentiated products and in some instances even within functionally identical products such as business jets, of which there continue to be many competing designs (Klepper, 1997: 172). Consequently, this current treatment of product customization activity neglects the important market pioneering effect of product customization and its implications for firm survival.

The study is therefore motivated by the need to unpack both the process of creation of new submarkets as well as the causal mechanisms linking product customization and firm survival. The limited understanding of the causal processes reflects, in part, the empirical challenges found in past research. Assessing the impact of product customization on firm survival hinges on identifying an industry where product customization has a high likelihood of leading to submarket pioneering. A robust estimation strategy further requires identifying other related industries where product customization does not necessarily lead to submarket pioneering beyond improving market-orientation à la Day (1994). Yet despite the identification of such industries, it is difficult to observe interactions between firms and potential users to develop custom products. The empirical challenge is only compounded by the need to measure product customization activity at the firm and preferably at the product level for a census of populations of firms spanning several related industries. An additional challenge in measurement stems from the difficulty in observing submarkets at a sufficiently disaggregated level.

To provide insight into the effect of product customization on firm survival and the key causal processes behind it, the study examines the range of production activities firms undertake: (i) production of a standard item; (ii) production of a custom item; (iii) design of and prototype of an item; and (iv) distribution and supply activities. I focus on the *upstream* laser industry where firms rely primarily on pioneering new submarkets for firm growth and survival (Klepper and Thompson, 2006). I use a previously unexplored data source, Photonics Spectra Buyers' Guide, which provides self-reported and corroborated measures of firm-product-level customization activity for the period 1997-2009. I estimate survival premium from undertaking product customization activity in the laser industry relative to other vertically related component and system industries and its impact on subsequent entry into the laser industry. The impact of product customization on firm survival can be confounded by several factors including firm-specific unobserved heterogeneity and observables such as vertical integration. Therefore, I use data on the *downstream* laser system industry to employ as a control group in some estimations and as the treatment group for some falsification tests where eleven other laser related industries are employed as the control group. I find that firms that undertake product customization activity survive longer in industries characterized by submarkets through two distinct mechanisms at two levels of analysis. At the firm level, product customization activity is associated with survival premium from submarket pioneering. At the industry level, product customization intensity is associated with a deterrence effect on subsequent entry, lower competition, and longer survival. These effects are robust to survival premium from multimarket competition and mutual forbearance.

The study contributes along three dimensions. First, by testing empirically the impact of product customization on firm survival I extend the submarkets model of industry evolution. I find that firms that undertake product customization activity survive longer in industries characterized by submarkets through two distinct mechanisms. Second, by examining the impact of the intensity of product customization at the product market level on subsequent entry and exit, I contribute to the literature in strategy and industrial organization on entry accommodation and deterrence. I find that the greater the fraction of firms in a given submarkets that undertake product customization activity the lower the level of entry in the next period. These results imply a deterrent effect of product customization that has not been previously anticipated in the submarkets model of industry evolution. Third, by unpacking the process of creation of new submarkets, I contribute a large-scale test of the impact of producer-user interaction on firm survival and innovation.

The study contributes a measurement innovation to the literatures on exploration and exploitation as well as on dynamic capabilities. Product customization that leads to submarket pioneering reflects the inherent trade-off between exploration and exploitation in new product development relative to mass production and it can complement patent-based measures of product-level firm-specific exploration-exploitation strategy (Katila and Ahuja, 2002; Benner and Tushman, 2003; Katila and Chen, 2008; Rosenkopf and McGrath, 2011). To the extent that undertaking product customization activity 'alters how a firm makes its living' by changing its submarket portfolio, customization reflects a dynamic rather than operational firm capability (Helfat and Winter, 2011).

The reminder of the paper is organized as follows. First, I elaborate on the pioneering and deterrent effects of product customization in industries featuring submarkets. Then I describe the industry context and data for the study. Next, I present econometric evidence and finally conclude with a discussion of the contribution and limitations of the study.

2. THE EFFECT OF PRODUCT CUSTOMIZATION ON FIRM SURVIVAL

The study of industries dominated by product customization can yield new insight into firm survival and yet it remains largely an underexplored domain. For example, Anderson and Tushman (1990: 628) emphasize the need to study such industries, noting that "While not investigated here, dominant designs might also not evolve in product classes with either limited demand or demand for custom-made products (Hounshell, 1984). Future research could more carefully explore the conditions under which industry standards do not emerge". Although product customization is observed in consumer goods industries, which remain the primary focus of research in strategy and marketing, international trade in intermediate inputs is dominated by customization. In examining international trade in electronics, automobiles & motocycles, and apparel & footwear, Sturgeon and

Memedovic (2011) exploit a novel classification in trade data for 50 products as "customized" or "generic." They find that customized intermediate inputs characterized by their use in one final product have grown in importance since 2001 relative to generic intermediate inputs used in a wide variety of final products. They also find that trade in customized intermediate inputs in electronics and autos dominates the world trade in all manufactured intermediate inputs. Given the growing importance of customized products, industry studies organizations such as United Nation's Industrial Development Organization are revising their Broad Economic Categories to incorporate generic vs. custom intermediate products classification (UNSD, 2013).

2.1 PIONEERING EFFECT OF CUSTOMIZATION ON FIRM SURVIVAL

Product customization that results in market pioneering can lead to a sustained competitive advantage and longer firm survival in an industry (Lieberman and Montgomery, 1988; Robinson et al, 1994). In industries featuring several submarkets, the role of market pioneering becomes more salient for firm survival. Who pioneers new submarkets? Prior literature has examined the factors that affect an incumbent's timing of entry into an emerging subfield. For example, Mitchell (1989) argues that an incumbent is more likely to enter an emerging submarket if its core submarkets are threatened and if it possesses industry-specific complementary assets, and enter early if it can resolve technical and market uncertainties sooner than others. Similarly, Franco et al (2009) argue that technical capabilities are complementary to early entry into an emerging submarket in conferring survival advantage. de Figueiredo and Silverman (2007) argue that a dominant incumbent is less likely to enter into adjacent submarkets that increase the likelihood of cannibalization of existing sales. While survival premium from early entry has been documented, Suarez and Lanzolla (2007) argue that industry conditions can amplify or dampen such advantages. Bhaskarabhatla and Klepper (2014) consider an industry where submarkets are limited in size and independent of each other on the demand and supply side. They argue that a lack of increasing returns to scale and scope in submarket-specific R&D investments implies that earlier entrants do not necessarily have a survival advantage. However, environmental shocks that increase demand for a submarket can unleash a process of that submarket becoming dominant leading to early mover advantages for firm survival.

In industries dominated by heterogeneity and uncertainty in customer needs, the industry expands by a proliferation of submarkets and product types. Scholars have modeled the evolution of industries featuring many submarkets. For example, Sutton (1998) argues that the extent to which a firm can dominate an industry by unilaterally escalating its R&D depends on the number of submarkets and the strength of linkages among them. Similarly, Klepper and Thompson (2006) propose a theory of industry evolution featuring submarkets. In their model, submarkets arrive exogenously at a constant rate and potential entrants have a constant probability of entering a new submarket. Firm size in a submarket is randomly determined upon entry and remains constant subsequently. Each submarket has a constant probability of destruction. Firm size remains constant for the duration of the submarket's life and then goes to zero as soon as the submarket is destroyed. The total firm size at any point in time is therefore the random sum of n draws, where n is the number of currently existing submarkets that the firm has entered. In the Klepper-Thompson model, entry, exit, and firm growth are driven entirely by the random birth and death of submarkets. While there is variation over time in industry and firm output, their model generates stable limiting distributions for the number of industry submarkets and the number of submarkets in which firms are active. A variant of the Klepper-Thompson model has been applied to two industries with low and high levels of submarket dynamics, namely tires and lasers, to explain industry evolution and shakeouts (Buenstorf and Klepper, 2010; Bhaskarabhatla and Klepper, 2014). These models predict that: (i) the probability of a firm being active in a given number of submarkets is directly related to the arrival rate of submarkets, λ, the probability of entry, θ, and firm age, s; and (ii) the probability of a firm exiting from the industry in some time period is strictly decreasing in the number of submarkets the firm is active in at the start of the period, n. Intuitively, firms can only exit in some period if all their submarkets are destroyed and they enter no new ones. Consequently, the more submarkets a firm is present in at the start of a period, the lower its chance of exiting in the time period. Building on this literature, if the probability of entering a new submarket is higher for firms that undertake product customization, then they have broader scope and longer survival.[1]

The literature on firm capabilities has also investigated product development processes and consequences for firm performance. For example, Danneels (2002) explores new product development strategies using five case studies and argues that leveraging existing technological competences to reach new customers requires firms to develop complementary customer competence or the ability to serve certain customers. Daneels (2008) terms such competences that allow for building new competences as second-order competences and notes that the empirical

[1] In the Klepper-Thompson model, suppose that there are two types of potential entrants, $C_1$and C_0 corresponding to firms that undertake product customization activity and others which do not and assume that experimentation and prototyping involved in product customization increase the probability of entering a new submarket such that $\theta_1 > \theta_0$. The size distributions of the two types of firms each have well-defined mean, variance, and coefficient of skewness. The absence of strategic interactions among heterogeneous firms implies that even if two separate pools of potential entrants with different entry probabilities are assumed to be present, the stationarity conditions of the Klepper-Thompson model are preserved. The precise expressions for the mean, variance, and coefficient of skewness of the overall size distribution are not important although it follows that the number of active submarkets of firms of type $j = 0, 1$ at age s is Poisson-distributed with mean $\theta_j \rho(s) = \theta_j \lambda \int_0^s [1 - exp\ (z)] dz$. Since $\theta_1 > \theta_0$ and λ and z are parameters, on average, firms at age s that undertake product customization enter into more submarkets and survive longer.

literature examining them is sparse. Similarly, Helfat and Winter (2011) define dynamic capabilities as those that 'alters how a firm makes its living.' To the extent that undertaking product customization activity changes a firm's submarket portfolio, customization reflects a dynamic rather than operational firm capability. More generally, product customization reflects a broader and deeper knowledge a firm posses about how the core technology can be modified to an emerging customer need and a firm competence that allows it to adapt to submarket obsolescence (Levinthal and March, 1993). Both the stylized models of industry evolution and the broader literature on dynamic capabilities lead to the first set of hypotheses:

H1a. Pioneering effect: Product customization activity is positively related to firm scope and survival.

H1b. Pioneering effect is stronger in industries with a higher submarket arrival rate (λ) relative to others.

2.2 DETERRENT EFFECT OF PRODUCT CUSTOMIZATION ON FIRM SURVIVAL

There are competing views on how the structure of markets and the behavior of incumbents affect rates of market entry and exit. In the economics literature, incumbent firms can credibly pre-commit to over-investing in capacity, product variety, or advertising to deter potential entrants from entering a market (see, Tirole, 1988; Bunch and Smiley, 1992). In a similar manner, Dewan, Jing, Seidmann (2003) argued that over-investment in product customization can also deter entry. In their theoretical model based a variation of Salop (1979), an incumbent monopolist can choose its extent of customization to maximize profits under the threat of potential entry by a second-mover. Customization activity serves as a credible pre-commitment signal to the potential entrants as customization requires introducing a degree of flexibility in production methods and thus it is costly to undertake. Yet product customization generates higher revenues and induces an optimal level of product customization by the incumbent monopolist. The authors find that an incumbent's ability to deter entry by undertaking customization activity increases as the cost of entry into a market increases and as the reservation price for the custom variety increases.

The deterrent effect associated with product customization intensity and submarket pioneering by an incumbent has not been previously investigated theoretically. While Dewan, Jing, and Seidmann (2003) is instructive, their model treats the overall size of the market as fixed (as in Salop, 1979) whereas customization can often open up new submarkets in some industries. In the Klepper-Thompson model, incumbents may be assumed to have a higher probability of entering a newly arising submarket if they have a higher number of submarkets (i.e., $\theta(n)$ increasing in n as opposed to all firms having the same probability of entry θ) and yet the additional survival premium generated from such a change only captures an increase in the pioneering effect rather than an effect due to entry deterrence. The survival premium from deterrence derives from incumbents' increased market power and the softening of competition due to a *decrease in net entry* into the submarket. The optimization problem of the firm within submarkets must be modeled explicitly in order to characterize the extent of survival premium due to deterrence whereas the focus in this research remains an empirical test of the deterrence proposition.

A competing view developed in organizational theory on how the structure of markets affects rates of market entry predicts albeit under certain conditions imitative entry (e.g., DiMaggio and Powell, 1983). According to this view, under uncertainty firms imitate each other and the greater the number of firms of a particular type in a market, the higher the probability of entry by firms of a similar type resulting in an *increase in net entry*. The empirical evidence, however, is mixed. For example, Haveman (1993) tested several variations of the hypothesis using subsample analyses of entry data in six submarkets of the savings and loan industry after deregulation in 1980. Haveman found support in half the estimations (15 out of 30, see Table 9 of the paper), particularly in submarkets where entry is spread over several years but not where entry is clustered in two or three years of the panel (see Table 1 of the paper) leaving open endogeneity concerns due to unobserved submarket effects. In examining the Manhattan hotel industry, Baum and Haveman (1997) found newly entering geographically proximate hotels to be similar on price but different on room size to incumbents. Overall, support for their third hypothesis reflects the dominance of the deterrent effect as new entrants similar both on price and size locate farther from established hotels in the vicinity. Several studies have identified boundary conditions for the imitation effect. For example, Haunschild and Miner (1997) distinguish imitation of an organizational practice based on the nature and extent of its prevalence from its impact on its uptake while Rao, Greve, and Davis (2001) document the transient and counterproductive nature of imitation as waves of imitative entry are followed by waves of exits. Nonetheless, the broader literature on sociology of organizations emphasizes mechanisms such as imitative entry under uncertainty and the role social identity and affiliations play in promoting imitative entry or mitigating competitive effects of entry (e.g., Greve, 1996; Ingram and Roberts, 2000). I expect imitative entry to play a role as considerable uncertainty prevails over potential size and competition in newly created submarkets (e.g., Chesbrough, 2003). Moreover, the creation of a new submarket can focus rivals' search for knowledge and attract late-movers (e.g., Katila and Chen, 2008). Which of the two effects dominates remains an empirical question. Building on the two perspectives, I develop the following hypotheses:

H2a. Deterrence Effect: The greater the fraction of firms that undertake product customization activity in period $t-1$, the lower the extent of entry and number of firms in period t.

H2b. Imitation Effect: The greater the fraction of firms that undertake product customization activity in period $t-1$, the greater the extent of entry by firms that undertake product customization in period t.

3. THE LASER AND RELATED INDUSTRIES CONTEXT

I test these hypotheses in the context of the laser industry, which is particularly suited for the study of submarket dynamics as it features various types of lasers each of which can be customized to pioneer new and independent submarkets (e.g., Klepper and Sleeper, 2005; Klepper and Thompson, 2006).

SUBMARKETS PIONEERING: THE CASE OF THE LASER-BASED HEARING AID

I begin with a case of submarket pioneering through product customization in the laser industry by a laser producer, Aculight. While traditional hearing aids involve the use of electrical signals to stimulate auditory nerves, laser-based hearing aids use optical signals. A university lab discovered the principle, for which Aculight developed a custom solidstate laser at the right wavelength. The head of business development at Aculight announced the novel product in a press release in 2008: "They [Vanderbilt University] demonstrated the basic concept using a free-electron laser. You want a wavelength that is absorbed sufficiently to stimulate the nerve without ablating the tissue and it turns out that 1.85 μm is one of those wavelengths. The group approached Aculight to provide a portable light source. Aculight responded with an engineering prototype based on a diode laser array." The firm later employed a Vanderbilt researcher as a liaison scientist and pioneered a new submarket for infrared nerve stimulators and marketed its product named Capella to several research organizations. Similar cases appear often in the trade literature, which is a characteristic of industries featuring submarkets such as lasers.

LASER MARKETS AND SUBMARKETS

Since their invention in 1960 the promise of lasers was apparent and yet a dominant application of the lasers was not, prompting some industry observers to describe lasers as *a solution looking for problems to solve*. Over time, thousands of new lasers have been developed and their discovery compiled by Weber (2001). Using the bibliography of Weber's book, I plot the timing of discovery of new lasers over time, as reflected by the number of new scientific articles in the four decades since their discovery first in 1960.

Insert Figure 1 about here

Figure 1 depicts waves of new lasers entering the industry and opening up new opportunities initially among gaseous lasing materials and subsequently in solidstate crystal and diode lasing materials. Klepper and Thompson (2006) note that although laser types identified based on lasing material are broader than laser submarkets, the predictions of their model hold provided laser submarkets are distributed randomly among laser types (see their footnote 13). In empirical analyses I control for the potential non-random allocation of submarkets to laser types.

Distinct variants of lasers engender their own distinct uses based on which materials absorb light from a variant of laser (Klepper and Sleeper, 2005). For example, a laser emitting red light can be used as a pointing device. In contrast, an infrared laser can be used to weld certain metals. Thus, historically, firms producing lasers have operated in a collection of independent submarkets with weak demand and supply-side linkages among them. While the presence of economies of scope on the production side cannot be completely discounted, the development of each laser type, even within a given technological trajectory, posed its own set of technical challenges. For example, gas lasers based on a helium and neon gas mixture were much simpler to design and produce, while those based on inert gases were notoriously difficult to develop and took much longer to commercialize. The presence of independent submarkets and the importance of product customization make lasers an ideal empirical setting for this study.

A fundamental challenge for firms in the laser industry remains discovering and developing new uses for lasers. Since the birth of the industry in 1960, the trade literature has reported laser firms pioneering new submarkets by establishing organizational units called 'application laboratories' or 'system engineering groups' (Laser Focus 1970, 1984). The leading laser firm, Coherent, established in 1966, pioneered various industrial uses of lasers using its application lab, as documented by its system engineers (Saunders and Bellis, 1980). Whereas identifying within-firm organizational structures is difficult, the data I use allow for distinguishing firms that customize products from others.

4. METHODS

4.1 Data Sources

The empirical challenge for the study has been described earlier. In examining the laser industry's evolution, prior studies used Laser Focus buyers' guides (Klepper and Sleeper, 2005, Klepper and Thompson, 2006). These data revealed rich and theoretically discriminating patterns of submarket dynamics (Bhaskarabhatla and Klepper, 2014). Yet the extent of product customization activity and producer-user interaction remained unmeasured.

Insert Figure 2 about here

The new data obtained from Photonics Spectra, an alternative buyers' guide meets the empirical challenge of this study in several aspects. First, Photonics Spectra's data are published electronically on compact disks during 1997-2009, which allows for the construction of a large panel across several industries whereas digitizing such information from printed catalogues would have been prohibitively expensive. Second, Photonics Spectra measures product customization activity in its annual survey of firms at the product level. As shown in Figure 2, the survey asks firms to identify for each product whether they manufacture standard versions of the product, whether they undertake the development of custom versions to meet unique user needs, whether they undertake design and prototype activities, and whether they serve as distributors or suppliers; claims which the editorial staff at Photonics Spectra reviews before publication ensuring a high degree of accuracy and reliability. Third, the survey also allows for the creation of new product categories. As new materials are discovered and new lasers are designed, custom applications for lasers emerge initially and become standard applications over time. The buyers' guide captures this essential feature in the laser industry. As Figure 2 shows, quantum cascade lasers, a type of newly discovered diode lasers identified by an asterisk is added to the questionnaire. The firm shown in Figure 2 designs and prototypes Q-Switched lasers; produces both stock and custom versions of the newly discovered quantum cascade lasers; and produces only custom versions of ruby crystal lasers. Finally, Photonics Spectra contains a rich set of control variables, which are difficult to collect for a population of predominantly privately owned firms.

Insert Table 1 about here

The dataset is based on this unusually rich 13-year (1997-2009) panel of respondents to Photonics Spectra's questionnaire, which spans several related industries listed in Table 1, 1,705 narrow submarkets, and 8,970 domestic (U.S.) and foreign firms. In this study, I focus particularly on a subset of 1029 firms that produce lasers, but I use the entire dataset to estimate returns to customization in lasers relative to other industries. The laser industry is composed of 80 different submarkets during this period composed of 21 gas, 28 solidstate, 23 diode, and 8 dye laser types. Each firm-year-product observation contains information about whether the firm can produce the standard or custom version of the product, whether it can design new variants of the product or if it is simply a distributor or a service firm. I augment the laser-industry dataset with data on firm-level annual patent counts for firms in the laser industry using data from Lai et al. (2011).

4.2 Estimation Strategy

The identification strategy relies on exploiting between-firm and between-industry variation in the self-reported measure of product customization activity. The measure of product customization is endogenous in the sense that better firms are more likely to be capable of and to actively participate in such activities. It may be argued that such firms survive longer in a submarket because of the inherent firm quality. In addition, among firms that undertake product customization, the cost of interpreting sticky user information, absorptive capacity, and the ability to integrate knowledge to develop a new product may differ, which may in turn be systematically correlated with unobserved firm quality. By exploiting the longitudinal nature of the data, I control for firm-specific time-invariant part of unobservables such as firm quality, which give rise to such endogeneity. I also control for a rich set of firm and market specific controls that mitigate the omitted variable bias. Since the data are a census of firms in the industries I study, the estimations do not suffer from selection bias. In order to further establish the validity of the results, I conduct falsification tests using the downstream laser system industry as the treatment group in place of the upstream laser device industry.

Dependent Variable

The primary dependent variable I use for several firm-level analyses is a dummy for firm exit, which is set equal to one in the year the firm exits a market and zero otherwise. The value is set equal to zero for the last year in our data, 2009, since I cannot observe if the firm has or has not produced in the subsequent year. In other firm-level regressions, I use the number of markets that a firm services in a given time period as a proxy for firm scope and the number of successful grants of patent applications by application year as a measure of innovation. At the industry-level, I use the number of firms in the market, entrants, and exits in a year as alternative dependent variables.

Explanatory and Control Variables

Table 2 contains a brief description of the explanatory and control variables. The four explanatory variables that relate to a firm’s production activities are Stock, Custom, Design, and Distributor. Each variable is a dummy set equal to one if the firm reports undertaking the associated activity in a given year. For example, if a firm reports in a given year undertaking the manufacture of stock items, which are prebuilt items for generic purposes, the measure Stock is set equal to one and zero otherwise. In contrast, Custom and Design measure firm activities to manufacture or design and prototype items to fit unique customer needs respectively. Distributor dummy identifies firms that engage in distribution and supply of products. These four measures are not mutually exclusive in the survey and firms may report undertaking multiple activities in a given year within a market. The two industry-level dummies for Laser and System are set equal to one when the product belongs to the upstream laser device or downstream laser system industry respectively and zero otherwise. Additional control variables include: Advertiser, a dummy for whether a firm pays Photonics Spectra additional fee to highlight its product entry in the Buyers’ Guide; Foreign, a dummy for non-U.S. firms; Integrated, a dummy for firms that produce upstream lasers and downstream laser systems in a given year; Preexisting Firm, a dummy for firms that existed at the start of the dataset in 1997; Product age, a time varying submarket-specific clock starting in 1997; and N firms, a variable measuring the number of firms in a submarket in an year. In addition, Gas, Dye, Solidstate, and Diode are four dummy variables identifying the type of each laser submarket.

Insert Table 2 about here

MODEL SPECIFICATION

I employ two classes of models in this study. First, for survival analyses, following Franco et al. (2009), I use a firm-product-year observation structure with complementary log-log specification, which allows for recovering continuous-time hazard rates from our annual data. This formulation allows for easier incorporation of time-varying covariates and controls for unobserved heterogeneity using random-effects specification. Fixed-effects models of this type are not estimable because a sufficient statistic allowing fixed-effects to be conditioned out of the likelihood does not exist and incorporating unconditional fixed-effects estimates with the use of firm dummies results in biased estimates. Therefore, I report results from linear probability model (OLS with a binary dependent variable) which is unbiased even if unconditional firm fixed effects are included as well as the admittedly biased complementary log-log regressions with unconditional firm fixed effects as robustness checks. Second, for count dependent variables, all of which have shown overdispersion, I use negative binomial regressions.

5. RESULTS

5.1 DESCRIPTIVES

Table 1 shows the list of 13 industries in the study. The laser industry accounts for 80 (4.7 percent) of the 1,705 products and 15,353 (3.6 percent) of the 428,471 firm-product-year observations. The downstream laser system industry accounts for 29,190 observations and 114 products. Descriptives for the four samples we use are shown in Table 3. The average percentage of firm-product-year observations that comprise firm exits from product markets in a given year is 14 to 15 percent in the overall sample as well as in the subsamples of laser and system industries, laser industry alone, and all industries excluding lasers. The probability of producing a stock item is 42 percent in the overall sample while it is higher in the subsamples of laser and system industries at 55 percent and 57 percent in the laser industry alone. In contrast, the percentage of firm-product-year observations with product customization activity is lower in the subsamples of laser and system as well as laser industries at 38 and 33 percent relative to 42 percent overall. Advertising intensity is similar in the laser and related industries at 29 percent. The laser industry has a higher representation of non-U.S. firms. The average number of firms in the laser and other related industries is comparable at 46 firms per market. Overall, based on these descriptive of the observables I argue that the set of related industries forms a good comparison group for the analysis of the laser industry. Pairwise correlations among these observables for the laser industry are shown in Table 4. The correlation between the probability of market exit and custom is -0.03 reflecting a weak unconditional relationship between firm exit and product customization activity. The correlation between Stock and Advertiser is 0.20 reflecting that firms that produce stock items are more likely to invest in advertising. Similarly, the correlation between foreign and Distributor is 0.16 reflecting that non-U.S. firms are more likely to identify themselves as distributors in the U.S. Table 4 provides a description of each of these variables.

Insert Tables 3 and 4 about here

5.2 PIONEERING EFFECT

I begin with results for the impact of product customization on the probability of a firm exiting the market shown in Table 5. The dependent variable for the analyses is the probability of market exit and the method of estimation is maximum likelihood for random effects complementary log-log regression. In column 1, the coefficient estimate of Stock is negative and significant reflecting a nine-percent lower probability of exiting the market in the overall sample. Similarly the coefficient estimates for Custom, Distributor, and Preexisting firm reflect a lower probability of firm exit. Of particular interest is the coefficient estimate of the interaction term between Custom and Laser, which is negative and significant at the 0.05 level reflecting a 13-percent additional decline in the probability of exit in the laser industry. The results indicate that while customization may be associated with a lower hazard of exit from the market across all industries, in the laser industry where submarkets are prominent, customization is associated with an additional survival premium.

Insert Table 5 about here

It may be argued that the overall set of 12 industries in the comparison group is composed of disparate products and while they are related to the laser industry and co-listed in the Buyers' Guide, a narrower set of products may serve as a more credible comparison group. Therefore, I limit the sample to Laser and System industries in column 2. The coefficient estimate of Custom X Laser is -0.12 and significant at the 0.05 level in column 2 reflecting that the survival premium is not driven by the choice of comparison industries. Next, I limit the sample to the laser industry in column 3 to identify the main effect of customization in the laser industry. It may be argued that firm survival differs across technological trajectories in the laser industry (e.g., gas, dye, solidstate, and diode) and product customization may differ by these trajectories. To avoid confounding the effect of product customization with technological trajectory effects, I include dummies for Gas, Solidstate, and Diode in column 3. The dummy for Dye is excluded due to perfect multicollinearity. The coefficient estimate of Custom in column 3 is -0.38, significant at the 0.01 level, and larger than the coefficient estimate of Stock, reflecting the higher survival premium associated with product customization in the laser industry relative to producing stock items. It may be argued that while customization is associated with a survival premium in the laser industry, such effect may also be present in the downstream laser system industry, which does not feature submarket pioneering through product customization to the same degree as does the upstream laser industry. I conduct a falsification test, where I remove observations for the laser industry from the overall sample and estimate survival premium from customization for the laser system producers. The coefficient estimate of Custom X System is 0.04 and not significant at the 0.1 level reflecting no additional survival premium relative to the average survival premium from customization of 14 percent in the subsample. These series of analyses robustly establish the nature and extent of survival premium from product customization activity associated with the laser industry.

Insert Table 6 about here

In the above analyses, I did not incorporate firm fixed effects because of the limitation of the complementary log-log regression. It may be argued that firm specific unobservables are a source of endogeneity confounding the effect of customization. To address these concerns, I employ three alternative methods and the results are shown in Table 6. First, following Franco et al. (2009), I use the values of explanatory variables for Stock, Custom, Distributor, and Design at the time of entry of a firm into a given product market as the values for all subsequent years in the panel. This procedure insulates these measures from panel evolution and thus from the evolution of firm-specific unobservables over time. The results, shown in column 5, remain qualitatively similar to those in column 3. Next, I employ the linear probability model and include unconditional firm fixed-effects in column 6. The coefficient estimate of Custom is negative and significant at the 0.01 level although the magnitude of the effect is smaller (-0.02) as the model does not account for the true range of the dependent variable. Notwithstanding the bias in unconditional fixed-effects estimation using the complementary log-log regressions, I show the estimates for completeness in column 7 and decompose them along laser technological trajectories in column 8. The coefficient estimate of Custom in column 7 is -0.29 and significant at 0.05 level, comparable to the random-effects estimations in columns 3 and particularly 5. The survival premium associated with product customization is likely to be higher in technological trajectories where the arrival rate of submarkets is higher, which are likely to be the newer trajectories such as Diode. Consistent with this view, the coefficient estimate of Custom X Diode is negative, significant, and larger than that for the other trajectories. Note that the main effects of the laser technological trajectories in estimations in column 8 are absorbed in market fixed-effects.

Insert Table 7 about here

Next, I analyze industry-level probability of exit, firm scope, and innovation as a function of product customization for the laser industry. The observation structure for these regressions is firm-year and consequently firm-product-year-level measures of Stock, Custom, Design, and Distributor do not readily apply at the firm-year level. Therefore, I use the following approach to construct dummy variables at the firm level: if a firm produces Stock variety for at least one product, then 'Stock at Firm Level' is set equal to one and zero otherwise. A similar procedure is followed for the construction of technological trajectory dummies at the firm level. The interaction dummies are set equal to one if a firm in a given year undertakes customization activity for at least one product in a particular trajectory and zero otherwise. The results are shown in columns 9 to 14 of Table 7. Customization is associated with: a lower probability of industry exit and particularly along the solidstate trajectory; a larger firm scope and particularly along solidstate and diode trajectories; and a greater patent propensity and particularly along the solidstate and diode trajectories. Note that the patent propensity regressions do not include firm fixed-effects as their inclusion drops 80 percent of the observations from the estimation sample due to a lack of within-firm variation in patenting.

Collectively, I argue that these results support the hypotheses that customization is associated with survival premium (H1a) and that it is stronger in the laser industry (H1b), which derives from firms in the laser industry with product customization pioneering more submarkets and having a broader scope.

5.3 Deterrent Effect

Next, I investigate the impact of the intensity of product customization on entry, density, and exits at the product market level. There are 19,579 market-year observations spanning 1,705 markets and 13 years. The results for negative binomial estimations are shown in Table 8. The number of firms in year t is the dependent variable in column 15 and one-period lagged values of explanatory variables are used, which reduces the number of market-year observations available for analysis to 17,669 because lagged values of the explanatory variables are not available for the year 1997. The coefficient estimate of L1.fCustom, which represents one-period lagged value of the fraction of firms in the market in a given year that report undertaking customization activity, is positive and significant at the 0.01 level reflecting that the higher the fraction of firms that undertake product customization in the last period, that greater is the number of firms in the market in the current period. The coefficient estimate of the interaction between L1.fCustom and Laser is negative and significant at 0.01 level and dominates the main effect of L1.fCustom reflecting the deterrent effect of product customization in the laser industry. A test of equality of the two coefficient estimates is rejected with $p < 0.01$. In column 16, N of Entrants is used as the dependent variable. Since I cannot distinguish entrants and incumbents in 1997 and their lagged values in 1998, the estimation is based on 16,329 market-year observations. The coefficient estimate of L1.fCustom is not significant in the overall sample and yet the coefficient estimate of its interaction with Laser is negative and significant at the 0.1 level reflecting the presence of deterrent effect on entry.

Insert Table 8 about here

In the subsample of laser and system industries, the coefficient estimate of L1.fCustom X Laser is negative and significant in column 17 at the 0.1 level and different from the main effect at $p < 0.01$ reflecting the dominance of the deterrent effect on the density of firms. The net effect of customization on entry in the laser industry in column 18 is positive as the main effect (1.85) is marginally larger and statistically different from the interaction effect (-1.64). I also conduct a falsification test by removing market-year observations specific to the laser industry and estimating L1.fCustom X System, which is positive and insignificant at the 0.1 level in columns 19 and 20. These results show that the deterrent effect is dominant in the laser industry, consistent with hypothesis H2a.

Insert Table 9 about here

Next, I test the impact of a change in the fraction of firms that undertake product customization on the number of entrants of the same type in the next period. The results of the estimation are shown in Table 9. The coefficient estimate of L1.fCustom is positive and significant in columns 21 through 23 reflecting imitative entry by firms that undertake customization. The coefficient estimate of the interaction term L1.fCustom X Laser is negative and large enough to nullify the main effect of imitative entry in column 21 but produces a net positive effect in column 22. The estimates of the falsification test in column 23 reflect that the effect is prominent in the laser industry as the coefficient estimate of L1.fCustom X System is not statistically significant. Whereas the results overall are consistent with hypothesis H2b, laser-specific results are not consistent.

Finally, I examine the impact of the intensity of product customization on the number of exits overall and those of firms undertaking product customization. The results are shown in columns 24 through 29 of Table 10. The coefficient estimate of L1.fCustom is positive in columns 25 reflecting an increase in the market-level exits due to an increase in the intensity of product customization. The coefficient estimate of L1.fCustom X Laser is however negative and dominates the main effect in columns 24 and 25 reflecting a lower number of market-level exits in the laser industry as the fraction of firms that undertake customization increases. The effect is prominent in the laser industry but not in the system industry as shown by the falsification test in column 26. I also examine in columns 27 through 29 exits among customizers. The coefficient estimate of L1.fCustom X Laser is negative and significant in the laser industry mitigating the effect of increased competition among customizers leading to exits overall as captured in the main effect. The additional impact is specific to the laser industry as reflected by the coefficient estimate of L1.fCustom X System in column 29.

Insert Table 10 about here

Collectively these results provide strong support for hypothesis H2a and reject hypothesis H2b in the laser industry. The results concerning exits also reflect the additional survival premium associated with entry deterrence at the market level.

5.4 Alternative Explanation: Multimarket Contact and Mutual Forbearance

I examine multiproduct firms in the laser and related industries. On average a firm is active in 52 product markets in a year in the dataset and the maximum is 195 markets. Even the bottom one percentile firms are present in an average of four product markets. The presence of firms in multiple product markets gives rise to multimarket contact, reduces rivalry due to mutual forbearance, and lowers exit rate from a market (e.g., Barnett, 1993; Jayachandran, Gimeno, and Rajan Varadarajan, 1999). The evidence I present both at the firm and market-level may be confounded by multimarket contact if product customization measure identifies firms and markets with greater multimarket contact. Consequently, at the firm-level I include a count measure of multimarket contact MMC_1, which is the average of the number of times a firm is present with rivals of the focal market in non-focal markets in a given year, as a robustness check (Gimeno and Woo, 1996). I average the mean firm-level multimarket contact variable to the market-level and include it in the market-level analyses of entry and exit rates. Whereas these measures are commonly used in the literature, they are sensitive to firm size and scope. Therefore, I construct alternative multimarket contact variables at the firm and market levels (MMC_2) by dividing the count measure MMC_1 by the number of focal firm's markets (e.g., Baum and Korn, 1996). The results of the estimations are shown in Tables 11 and 12 for firm and market-levels respectively. The coefficient estimate of multimarket contact is negative and significant in columns 30 through 33 reflecting that multimarket contact leads to a lower firm hazard of market exit. The coefficient estimate of the interaction term Custom X Laser is negative and significant in columns 30 and 32, reflecting an additional lower hazard of exit for firms undertaking product customization in the laser industry. Multimarket contact variables are not statistically significant at the market-level analyses in columns 34 to 39. The coefficient estimate of L1.fCustom X Laser is negative and significant in columns 34 through 39, reflecting the robustness of results to the inclusion of multimarket contact measures. Anand, Mesquita, and Vassalo (2009) argue that firms undertaking exploratory strategies seek to reduce uncertainty through imitative entry and exit. The results of this study show that the deterrent effect associated with exploration intensity can lower the extent of such imitative entry and exit.

Insert Tables 11 and 12 about here

6. DISCUSSION

The study of industries dominated by product customization and multiple submarkets is under-represented in the literature on strategy and organization theory although customization of products in general and of intermediate inputs in particular has been on the rise. Theories of industry evolution based on the traditional mass-production view are ill-suited to explain firm survival and dynamics of entry and exit in industries characterized by submarkets. While the nature of production technology can often determine the extent of product customization and the abundance of submarkets as in the case of the laser industry, a growing pattern of differentiated consumer preferences can also give rise to product customization and the proliferation of submarkets. Early theorizing in economics and strategy featuring the concept of submarkets has treated them as arriving exogenously and randomly, paying little attention to the consequences of firms' own activities to influence their arrival. However, in reality, firms build organizational structures and processes to recognize and respond to opportunities in their environment. The quality of such organizational structures and processes explain firm growth and survival in industries characterized by a degree of churn in market opportunities. Yet despite the innocuous nature of the argument, its test is fraught with challenges in measurement, isolating mechanisms, and identifying causal impacts. A careful examination of causal mechanisms can reveal the direct benefits of firm-specific activities anticipated by the current theorizing on the topic and surprising indirect, dynamic, industry-level effects.

I took up these issues in this research. I described how firms in the upstream laser device industry established organizational units called application laboratories and interacted with potential users across several industries to pioneer several submarkets. In particular, I illustrated the process using the case of laser-based hearing aid. I then tested the two main propositions concerning submarket pioneering and entry deterrence effects of product customization that cause firms to survive longer in industries characterized by submarkets. I showed that product customization in a market lowered the hazard of exit from the market, particularly in the laser industry where customization can lead to pioneering new submarkets. Product customization also lowered the number of firm exits due to a decline in entry and the intensity of competition. The study established the robustness of these results using several comparison and falsification tests and alternative estimation methods.

The findings of this study relate to the broader literatures in economics and sociology beyond industry evolution. First, the study contributes to the growing theoretical and empirical literature on submarket based models of industry evolution by clarifying the distinct mechanisms of firm survival. Second, the study contributes to the literature in sociology of organizations by clarifying the boundary conditions for conformist or imitative entry of successful firms. Product customization leads to success in a submarket as such firms face better odds of survival. Yet the presence of a larger fraction of firms with product customization does not necessarily lead to more firms of the same type from entering the submarket.

Third, in terms of measurement, product customization activity changes a firm's portfolio of submarkets. In this sense, product customization can alter the way in which a firm makes its living and qualifies as a dynamic rather than operational firm capability. Similarly, submarket pioneering through product customization represents exploration whereas a focus on the production of stock items represents exploitation. I showed that an increase in the fraction of firms that undertake exploratory search lowers further entry into the submarket. Therefore, the study complements the literature on within-firm tradeoff between exploration and exploitation by identifying industry-level dynamic, indirect effects.

Finally, rarely if ever have studies on user innovation measured producer-user interaction for a population of firms in an industry. In examining two industries where product customization dominates, von Hippel (1998) argues with case studies that users face lower information and transaction costs of customizing products rather than suppliers of intermediate inputs. Therefore, he suggests that the suppliers of intermediate inputs may profitably cede to users "application-specific portion of the problem-solving work of custom product and service design" [emphasis not added]. However, considerable between-supplier variation in customization activity can exist even in these product markets and consequences for the relative survival of firms that do take up customization activity remain unclear in the absence of a careful empirical test. This study contributes to the user innovation literature by documenting within-industry and within-submarket variation in firm-level product customization activity, which involves producer-user interaction, and by conducting a large-scale empirical test of the impact of such interaction for a population of firms whereas previous work examined patent data (e.g., Chatterji and Fabrizio, 2012). While not all firms that report undertaking product customization activity interact with and involve potential users to the same degree and succeed in customization to the same degree, the average positive effect on firm survival indicates a clear and robust competitive advantage for some producers that involve users in new product development.

Several issues remain to be addressed in future research. Whereas the study provides strong evidence that product customization activity causes firms to survive longer in industries characterized by submarkets, future research could deepen our understanding of the heterogeneity in the organization of search for submarkets and its differential consequences. Although I documented the positive impact of product customization in the laser industry for incumbents, future studies could examine other industries and stages of the industry life cycle where product customization can lead to negative effects. Historically, the automobile industry in the U.S. was characterized by a period of intense experimentation until the mid-1900s followed by the dominance of mass production until the mid-1920s and subsequently the return of product customization through annual revision of vehicle models and the proliferation of product varieties (Hounshell, 1984). Such customization was attributed to the revival of General Motors and the weakening of Ford's market position built largely on mass production of a standardized product. These anecdotes indicate the uneven impact of product customization on firm survival over the industry life cycle.

Another promising research avenue is the investigation of the impact of product customization on the geography of industries. Klepper and Sleeper (2005) show that although the overall laser industry did not cluster regionally in the U.S., intra-industry spinoffs did cluster and they were also more likely to survive longer. Klepper (2007) and Klepper and Thompson (2010) argued that such intra-industry spinoffs across industries resulted from the parent firm's reluctance to pursue custom product varieties that would meet the needs of submarkets. Therefore, does product customization lead to the clustering for successful firms in an industry and deter other regions from gaining a foothold? Future research can investigate these questions.

Overall, this study builds on the existing literature, extending the submarkets model of industry evolution and enriching it with complementary perspectives from industrial organization and sociology of organizations. Findings suggest that product customization confers additional longevity for firms in the laser industry, characterized by its many submarkets whereas such effects may be weaker in other industries characterized fewer submarkets. Yet a preliminary analysis suggests that product customization may be beneficial even in industries characterized by a low arrival rate of submarkets (λ). For example, while the pioneering effect does decline with λ as reflected by hypothesis H1a, the extent of advantage of preempting others from entering new submarkets or gaining first mover advantage may actually increase as λ decreases. While this research has taken the first step to investigate these effects empirically, the development of a richer analytical theory of submarkets incorporating such strategic effects is necessary to characterize the full set of consequences of product customization for firm survival.

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FIGURES AND TABLES

Figure 1. N of scientific articles reporting new laser discoveries over four decades by technology

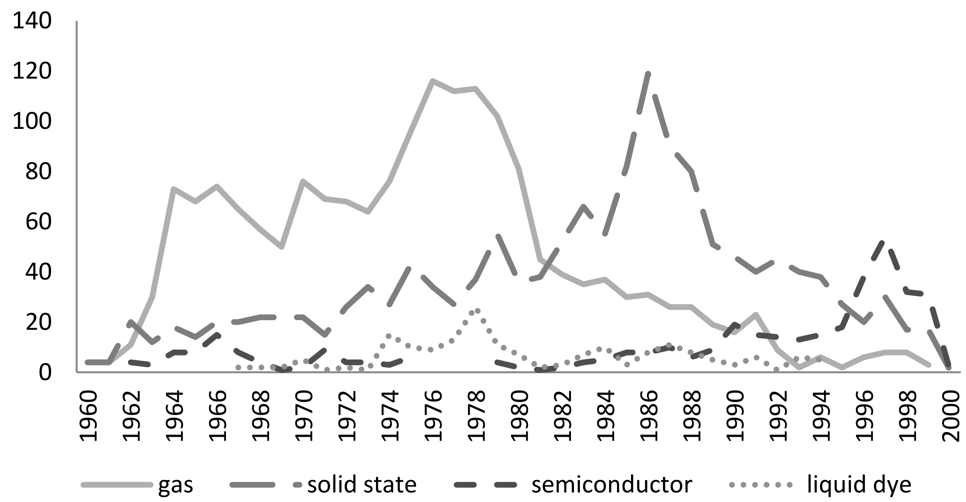

Figure 1 Notes—Figure 1 is constructed by the author based on the list of references in Weber (2001)—a comprehensive compilation of scientific articles reporting the discovery of new lasers—by technological trajectory. It anticipates the extent of product variety in the upstream laser industry.

Figure 2. Questionnaire of Photonics Spectra Buyers' Guide

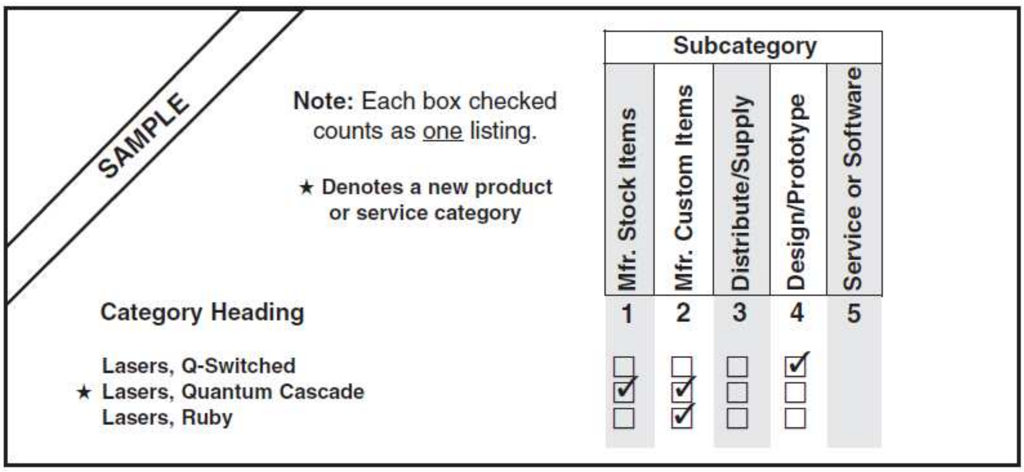

Figure 2 Notes—Figure 2 depicts a snippet from the Photonics Spectra Buyers' Guide that captures product-level firm-specific production activities. The measures of production activity are not mutually exclusive. A firm may report undertaking the manufacture of Stock items as well as Custom items.

Table 1. Industries in Photonics Spectra Buyers' Guide

#	Industry	N	Products	Companies
1	Upstream Laser Device	15,353	80	1,029
2	Downstream Laser System	29,190	114	2,397
3	Detector	10,131	41	1,066
4	Electronics	15,283	80	1,519
5	Fabrication	19,274	68	1,921
6	Fiber	48,884	185	2,771
7	Imaging	45,723	208	2,869
8	Light	13,590	58	1,047
9	Material	23,589	101	1,736
10	Optical	113,233	335	3,698
11	Position	18,558	82	1,481
12	Service	34,094	127	3,161
13	Testing	41,569	226	2,866
Total		428,471	1,705	27,561

Table 1 Notes—Table 1 lists the thirteen vertically related industries in the broader photonics and optoelectronics industries with a particular focus on the upstream laser device (referred to as the Laser industry) and downstream laser system (referred to as the System industry) industries. The industries are classified by Photonics Spectra based on products.

Table 2. Description of Variables

Variable	Description
Probability of Exit	= 1 if a firm exits a market in a year and zero otherwise
Stock, Custom, Design, Distributor	= 1 if a firm reports producing stock, custom, design, or distributor item in a market and zero otherwise
fStock, fCustom, fDesign, fDistributor	Fraction of firms in a market in an year that undertake the production of stock, custom, design, or distribute items
Stock (Custom, Design, Distributor) at Firm Level	= 1 if a firm reports producing stock, custom, design, or distribute item at entry in a market and zero otherwise
Foreign, Advertiser	= 1 if a firm is non-U.S.-based or advertiser and zero otherwise
Preexisting Firm	= 1 if a firm is present in a market in 1997, the year our dataset begins, and zero otherwise
N of Firms	Measures the number of firms in a market in a year
Product Age	Measures the age of the submarket since starting year and 1997 for preexisting markets
Firm Scope	Measures the number of distinct markets a firm is active in a year in the laser industry
Gas, Dye, Solidstate, Diode	= 1 if a firm in a year produces in a market categorized in the Buyer's Guide as belonging to Gas, Dye, Solidstate, or Diode technological trajectory in the laser industry and zero otherwise
Vertical Integration	= 1 if a firm produces a laser and a laser-based system in a month and zero otherwise
MMC_1, MMC_2	The average of the number of times a firm is present with rivals of the focal market in non-focal markets in a given year at the firm level. MMC_2 is obtained by dividing MMC_1 by firm scope.

Table 3. Summary Statistics for Variables in the Data for Four Samples

Sample (N)	All Industries (428,471)				Laser & System (44,543)				Laser Alone (15,353)			
Variable	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
P[Market Exit]	0.14	0.35	0	1	0.15	0.36	0	1	0.15	0.36	0	1
Stock	0.48	0.50	0	1	0.55	0.50	0	1	0.57	0.50	0	1
Custom	0.42	0.49	0	1	0.38	0.48	0	1	0.33	0.47	0	1
Distributor	0.18	0.39	0	1	0.19	0.39	0	1	0.26	0.44	0	1
Design	0.14	0.35	0	1	0.14	0.35	0	1	0.11	0.31	0	1
Advertiser	0.29	0.46	0	1	0.24	0.42	0	1	0.29	0.45	0	1
Foreign	0.25	0.43	0	1	0.37	0.48	0	1	0.44	0.50	0	1
Integrated	0.12	0.33	0	1	0.50	0.50	0	1	0.70	0.46	0	1
Preexisting Firm	0.46	0.50	0	1	0.41	0.49	0	1	0.36	0.48	0	1
Product age	5.78	3.69	0	12	5.88	3.70	0	12	5.87	3.66	0	12
N firms	46.94	37.56	1	195	44.15	33.15	1	131	46.76	40.53	1	131

Table 4. Pair-wise correlations in the Laser Industry (N=15,353; † not significant at $p = 0.1$)

Variable	#	1	2	3	4	5	6	7	8	9	10
P[Market Exit]	1	1									
Stock	2	0.00†	1								
Custom	3	-0.03	-0.07	1							
Distributor	4	-0.04	-0.61	-0.31	1						
Design	5	0.02	-0.09	0.16	-0.14	1					
Advertiser	6	-0.04	0.20	0.09	-0.09	0.01†	1				
Foreign	7	-0.02	-0.12	-0.10	0.16	-0.09	-0.23	1			
Integrated	8	0.00†	0.01†	-0.07	0.00†	-0.08	0.16	-0.09	1		
Preexisting Firm	9	-0.04	0.00†	-0.05	0.03	-0.03	-0.01†	-0.05	0.03	1	
Product age	10	-0.07	0.00†	0.03	0.01†	-0.04	0.03	0.03	-0.02	-0.33	1
N firms	11	-0.05	-0.06	-0.04	0.11	-0.01†	-0.08	0.09	0.05	-0.02	0.17

Table 5. Probability of Market Exit as a Function of Product Customization Activity

Column #	1		2		3		4	
Estimation Method	ML for Complementary log-log, Random Effects							
Sample	All Industries		Laser & System		Laser Only		All Except Laser	
D.V.=P[Market Exit]	coef	se	coef	se	coef	se	coef	se
Stock	-0.09*	[0.01]	-0.18*	[0.04]	-0.28*	[0.07]	-0.09*	[0.01]
Custom	-0.14*	[0.01]	-0.16*	[0.04]	-0.38*	[0.06]	-0.14*	[0.01]
Distributor	-0.04*	[0.02]	-0.09	[0.06]	-0.54*	[0.09]	-0.04†	[0.02]
Design	0.01	[0.02]	-0.03	[0.05]	0	[0.08]	0.01	[0.02]
Stock X Laser	0	[0.04]	0.06	[0.05]				
Custom X Laser	-0.13†	[0.05]	-0.12†	[0.06]				
Design X Laser	0.13	[0.08]	0.15‡	[0.09]				
Distributor X Laser	-0.32*	[0.06]	-0.29*	[0.07]				
Advertiser	-0.09*	[0.01]	0.01	[0.04]	-0.18*	[0.06]	-0.08*	[0.01]
Foreign	0.04*	[0.01]	0.02	[0.03]	-0.13†	[0.05]	0.05*	[0.01]
Integrated	0.21*	[0.02]	0.05	[0.03]	-0.02	[0.06]	0.22*	[0.02]
Preexisting firm	-0.27*	[0.01]	-0.14*	[0.04]	-0.21*	[0.08]	-0.27*	[0.01]
Product age	0.03*	[0.00]	0.03†	[0.01]	0.06*	[0.02]	0.02*	[0.00]
N of firms in market	-0.00*	[0.00]	-0.00*	[0.00]	-0.00*	[0.00]	-0.00*	[0.00]
Gas					-0.16	[0.13]		
Solidstate					-0.11	[0.13]		
Diode					0.04	[0.13]		
Stock X System							-0.02	[0.03]
Custom X System							0.04	[0.03]
Design X System							0.03	[0.05]
Distributor X System							0	[0.05]
Constant	-1.60*	[0.03]	-1.36*	[0.08]	-1.05*	[0.20]	-1.61*	[0.03]
N	428,471		44,543		15,353		413,118	
Year FE	YES		YES		YES		YES	
Firm RE	YES		YES		YES		YES	
Wald Stat	3474*		225.3*		165.8*		3382*	
Log pseudolikelihood	-165174		-18060		-6134		-158996	

Firm-clustered standard errors in brackets; *p<0.01, † p<0.05, ‡ p<0.1

Table 5 Notes: The method of estimation is maximum likelihood (ML) for conditional RE complementary log-log regression. The full sample, used in column 1, contains 1,705 product markets spanning 13 industries in the Photonics Spectra Buyers' Guide including upstream laser devices and downstream laser systems industries. A subsample of upstream and downstream laser industries is used in column 2 and a subsample of upstream laser industry alone is used in column 3. For the falsification test, upstream laser industry observations are removed from the full sample, resulting in 428,471-15,353=413,118 observations in column 4. The sample period is from 1997 to 2009. The dependent variable is a binary variable set to one in the year a firm exits the product market. The explanatory variables are described in the main text as well as in Table 2.

Table 6. Probability of Laser Market Exit as a Function of Product Customization Activity

Column #	5		6		7		8	
Estimation Method	Panel, cloglog		Pooled OLS		Pooled, cloglog		Pooled, cloglog	
D.V.=P[Market Exit]	coef	se	coef	se	coef	se	coef	se
Stock at Entry	-0.18†	[0.07]						
Custom at Entry	-0.27*	[0.07]						
Distributor at Entry	-0.44*	[0.09]						
Design at Entry	0.04	[0.08]						
Stock			-0.03*	[0.01]	-0.25‡	[0.15]	-0.25	[0.15]
Custom			-0.02*	[0.01]	-0.29†	[0.12]		
Custom X Gas							-0.35‡	[0.19]
Custom X Solidstate							-0.25‡	[0.14]
Custom X Diode							-0.44†	[0.18]
Custom X Dye							0.46	[0.33]
Distributor			-0.02	[0.01]	-0.23	[0.19]	-0.21	[0.19]
Design			-0.03†	[0.01]	-0.27	[0.17]	-0.26	[0.17]
Advertiser	-0.21*	[0.06]	0.02†	[0.01]	0.55*	[0.14]	0.55*	[0.14]
Foreign	-0.14†	[0.05]	0	[0.02]	0.15	[0.24]	0.12	[0.25]
Integrated	-0.01	[0.06]	-0.04†	[0.01]	-0.46†	[0.20]	-0.45†	[0.20]
Preexisting firm	-0.20†	[0.08]	0	[0.01]	0.04	[0.12]	0.03	[0.12]
Product age	0.06*	[0.02]	0.01	[0.01]	0.07	[0.13]	0.06	[0.13]
N Firms	-0.00*	[0.00]	0	[0.00]	0	[0.00]	0	[0.00]
Constant	-1.26*	[0.16]	-0.22*	[0.04]	-18.89*	[1.30]	-19.91*	[1.30]
N	15,353		15,353		15,353		15,353	
Year FE	YES		YES		YES		YES	
Firm RE/FE	RE		FE		FE		FE	
Market FE	--		YES		YES		YES	
Wald/F/Chi2 Stat	135.5*		7.32*		3112*		3118*	
Log pseudo likelihood/ R Squared	-6149		0.367		-3407		-3404	

Firm-clustered standard errors in brackets; *p<0.01, † p<0.05, ‡ p<0.1

Table 6 Notes: The method of estimation is maximum likelihood for panel complementary log-log regression with random effects for column 5, ordinary least squares for column 6, and pooled complementary log-log for columns 7 and 8. Subsample of upstream laser industry alone is used in columns 5-8. The sample period is from 1997 to 2009. The dependent variable is a binary variable set to one in the year a firm exits the product market. Firm exits in 2009 are treated as censored. The explanatory variables are described in the main text.

Table 7. Impact of Product Customization on Firm Survival, Scope, and Patents

Column #	9		10		11		12		13		14	
D.V.=	P[Laser Industry Exit]				N of Laser Markets				N of Laser Patents			
Estimation Method	Panel RE, complementary log-log				Panel FE, negative binomial				Pooled, negative binomial			
Estimates	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se
Stock at Firm Level	-0.18	[0.13]	-0.19	[0.13]	0.34*	[0.06]	0.38*	[0.06]	0.22	[0.28]	0.16	[0.26]
Custom at Firm Level	-0.47*	[0.11]	-0.07	[0.28]	0.30*	[0.04]	0.04	[0.07]	0.68†	[0.29]	-0.86‡	[0.48]
Design at Firm Level	-0.03	[0.14]	-0.04	[0.14]	0.05	[0.05]	0.04	[0.05]	0.15	[0.23]	0.09	[0.23]
Distributor at Firm Level	-0.45*	[0.15]	-0.48*	[0.15]	0.04	[0.06]	0.06	[0.06]	-1.70*	[0.40]	-1.71*	[0.39]
Gas at Firm Level	-0.26†	[0.13]	-0.22	[0.14]	1.00*	[0.08]	0.97*	[0.08]	0.43	[0.35]	0.06	[0.38]
Dye at Firm Level	0.06	[0.16]	0.16	[0.18]	0.37*	[0.06]	0.40*	[0.07]	0.6	[0.43]	1.08†	[0.49]
Solidstate at Firm Level	-0.41*	[0.11]	-0.32†	[0.13]	1.26*	[0.07]	1.21*	[0.07]	0.57†	[0.24]	0.1	[0.24]
Diode at Firm Level	-0.46*	[0.12]	-0.44*	[0.13]	0.67*	[0.05]	0.61*	[0.05]	1.71*	[0.28]	1.37*	[0.29]
Custom X Gas at Firm Level			-0.3	[0.29]			0.18†	[0.08]			0.97‡	[0.57]
Custom X Dye at Firm Level			-0.44	[0.35]			-0.08	[0.08]			-1.68*	[0.59]
Custom X Solidstate at Firm Level			-0.42‡	[0.25]			0.22*	[0.07]			1.50*	[0.44]
Custom X Diode at Firm Level			-0.22	[0.27]			0.23*	[0.07]			1.26†	[0.51]
Preexisting firm	-0.21	[0.14]	-0.2	[0.14]	0.02	[0.04]	0.03	[0.04]	0.34	[0.34]	0.32	[0.32]
Integrated	-0.05	[0.10]	-0.05	[0.10]	0.41*	[0.05]	0.43*	[0.05]	0.06	[0.30]	0.16	[0.27]
Foreign	0.06	[0.10]	0.05	[0.10]	0.10‡	[0.06]	0.17*	[0.06]	-0.74*	[0.27]	-0.66†	[0.26]
Constant	-1.25*	[0.31]	-1.32*	[0.32]								
N	4,993		4,993		4,993		4,993		4,993		4,993	
Year FE	YES		YES		YES		YES		YES		YES	
Firm RE/FE	RE		RE		FE		FE		NA		NA	
Wald Stat	63.8*		65.28*		1915*		1970*		400.9*		503.2*	
Log pseudolikelihood	-1751		-1749		-4110		-4099		-1919		-1903	

Firm-clustered standard errors in brackets; * p<0.01, † p<0.05, ‡ p<0.1

Table 7 Notes: See notes for Table 5.

Table 8. Impact of product customization on N of Firms and Entry at the market level

Column #	15		16		17		18		19		20	
D.V.=	N Firms		N Entrants		N Firms		N Entrants		N Firms		N Entrants	
Sample	All Industries				Laser & System				All Except Laser			
Estimates	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se
L1.fStock	-0.72*	[0.13]	-0.70*	[0.11]	0.14	[0.58]	0.03	[0.53]	-0.73*	[0.13]	-0.70*	[0.11]
L1.fCustom	0.34*	[0.12]	0.17	[0.11]	1.87*	[0.71]	1.85*	[0.61]	0.28†	[0.12]	0.12	[0.11]
L1.fDesign	-0.09	[0.19]	-0.01	[0.16]	1.01	[0.85]	0.61	[0.70]	-0.13	[0.20]	-0.04	[0.17]
L1.fDistributor	-0.19	[0.14]	-0.25†	[0.12]	2.62*	[0.93]	2.15†	[0.86]	-0.29†	[0.14]	-0.33*	[0.12]
L1.fStock X Laser	0.39	[0.40]	0.71†	[0.33]	0.86‡	[0.44]	1.19*	[0.38]				
L1.fCustom X Laser	-1.66*	[0.58]	-0.85‡	[0.49]	-2.16*	[0.77]	-1.64†	[0.66]				
L1.fDesign X Laser	-0.66	[0.91]	-1.01	[0.79]	-0.8	[1.19]	-0.78	[1.03]				
L1.fDistributor X Laser	1.40‡	[0.84]	0.4	[0.66]	0.21	[1.16]	-0.57	[0.97]				
L1.fStock X System									-0.68†	[0.31]	-0.60†	[0.25]
L1.fCustom X System									0.39	[0.67]	0.65	[0.55]
L1.fDesign X System									0.08	[0.82]	-0.31	[0.66]
L1.fDistributor X System									1.60‡	[0.87]	1.30‡	[0.77]
Constant	3.28*	[0.12]	1.09*	[0.09]	1.74*	[0.53]	-0.28	[0.51]	3.33*	[0.12]	1.13*	[0.10]
N	17,669		16,329		2,055		1,905		16,870		15,586	
Year FE	YES		YES		YES		YES		YES		YES	
Wald Stat	320*		1382*		70*		218*		323*		1399*	
Log likelihood	-72101		-36942		-8094		-4259		-68984		-35237	

Market-clustered standard errors in brackets; * $p<0.01$, † $p<0.05$, ‡ $p<0.1$

Table 8 Notes: Negative binomial regressions with the dependent variables N of Firms and N of Entrants. The explanatory variables are one-period lagged values of the fraction of firms in the market with stock, custom, design, distribution activity. The full sample consists of 19,239 Market-Year observations for the period 1997-2009. Observations for 1997 are excluded for N Firms regressions and 1997-1998 for N Entrants regressions.

Table 9. Impact of product customization on N of Entrants Undertaking Product Customization

Column #	21		22		23	
D.V.=	N of Entrants Undertaking Product Customization					
Sample	All Industries		Laser & System		All Except Laser	
Estimates	coef	se	coef	se	coef	se
L1.fStock	-0.19	[0.13]	-0.28	[0.49]	-0.19	[0.13]
L1.fCustom	2.16*	[0.12]	1.95*	[0.56]	2.16*	[0.13]
L1.fDesign	-1.00*	[0.18]	0.82	[0.63]	-1.11*	[0.18]
L1.fDistributor	-0.57*	[0.14]	2.05†	[0.83]	-0.68*	[0.14]
L1.fStock X Laser	0.87*	[0.30]	1.26*	[0.38]		
L1.fCustom X Laser	-2.00*	[0.44]	-1.59*	[0.61]		
L1.fDesign X Laser	0.56	[0.73]	-1.05	[0.91]		
L1.fDistributor X Laser	0.91	[0.67]	-1.36	[0.97]		
L1.fStock X System					-0.42	[0.26]
L1.fCustom X System					-0.5	[0.48]
L1.fDesign X System					1.72*	[0.62]
L1.fDistributor X System					2.46*	[0.75]
Constant	-0.72*	[0.12]	-0.87‡	[0.45]	-0.73*	[0.12]
Observations	16,329		1,905		15,586	
Year FE	YES		YES		YES	
Wald Stat	1023*		142*		1025*	
Log likelihood	-23867		-2808		-22775	

Market-clustered standard errors in brackets; * p<0.01, † p<0.05, ‡ p<0.1

Table 9 Notes: Negative binomial regressions with the dependent variables N of Firms and N of Entrants. The explanatory variables are one-period lagged values of the fraction of firms in the market with stock, custom, design, distribution activity. The full sample consists of 19,239 Market-Year observations for the period 1997-2009. Observations for 1997 are excluded for N Firms regressions and 1997-1998 for N Entrants regressions.

Table 10. Impact of Product Customization on N of Exits at the Market Level

Column #	24		25		26		27		28		29	
D.V.=	N of Exits						N of Exits by Customizers					
Sample	All Industries		Laser & System		All Except Laser		All Industries		Laser & System		All Except Laser	
Estimates	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se
L1.fStock	-0.58*	[0.11]	0.02	[0.46]	-0.59*	[0.12]	-0.09	[0.13]	0	[0.45]	-0.09	[0.13]
L1.fCustom	0.04	[0.11]	1.27†	[0.53]	-0.01	[0.11]	2.40*	[0.12]	2.37*	[0.51]	2.40*	[0.13]
L1.fDesign	0	[0.17]	0.85	[0.69]	-0.04	[0.18]	-0.89*	[0.18]	0.76	[0.65]	-1.01*	[0.19]
L1.fDistributor	-0.27†	[0.13]	1.89†	[0.78]	-0.33*	[0.13]	-0.58*	[0.14]	1.75†	[0.71]	-0.66*	[0.14]
L1.fStock X Laser	0.39	[0.29]	0.77†	[0.35]			0.43‡	[0.26]	0.70†	[0.35]		
L1.fCustom X Laser	-1.26*	[0.40]	-1.71*	[0.57]			-1.94*	[0.36]	-1.63*	[0.56]		
L1.fDesign X Laser	-0.38	[0.69]	-0.53	[0.92]			0.59	[0.61]	-0.79	[0.84]		
L1.fDistributor X Laser	0.87	[0.65]	-0.11	[0.92]			1.19‡	[0.62]	-0.71	[0.85]		
L1.fStock X System					-0.50‡	[0.26]					-0.35	[0.28]
L1.fCustom X System					0.4	[0.51]					-0.32	[0.50]
L1.fDesign X System					0.15	[0.70]					1.52†	[0.65]
L1.fDistributor X System					1.18‡	[0.71]					2.03*	[0.65]
Constant	1.78*	[0.10]	0.48	[0.43]	1.82*	[0.11]	-0.33*	[0.12]	-0.80†	[0.39]	-0.32*	[0.12]
N	16,073		1,875		15,347		16,073		1,875		15,347	
Year FE	YES		YES		YES		YES		YES		YES	
Wald Stat	578*		114*		571*		812*		83*		817*	
Log likelihood	-37431		-4251		-35818		-23773		-2717		-22792	

Market-clustered standard errors in brackets; * p<0.01, † p<0.05, ‡ p<0.1

Table 10 Notes: The method of estimation is maximum likelihood for negative binomial regression. The dependent variables are N of Exits by market by year and N of Exits by firms that do not produce custom products. All explanatory variables are lagged by one period. The sample for estimations is drawn from the full sample of 19,329 Market-Year observations after excluding year 1997 and 2009 because the lagged values are missing for 1997 and exits are censored for 1999.

Table 11. Probability of Market Exit as a Function of Product Customization Activity

Column #	30		31		32		33	
Estimation Method	ML for Complementary log-log, Random Effects							
Sample	All Industries		All Except Laser		All Industries		All Except Laser	
D.V.=P[Market Exit]	coef	coef	coef	se	coef	se	coef	se
MMC_1	-0.01*	[0.00]	-0.01*	[0.00]				
MMC_2					-0.46*	[0.04]	-0.48*	[0.04]
Stock	-0.10*	[0.01]	-0.09*	[0.01]	-0.07*	[0.01]	-0.06*	[0.01]
Custom	-0.14*	[0.01]	-0.14*	[0.01]	-0.11*	[0.01]	-0.11*	[0.01]
Distributor	-0.05*	[0.02]	-0.04†	[0.02]	-0.02	[0.02]	-0.02	[0.02]
Design	0	[0.02]	0	[0.02]	0.02	[0.02]	0.02	[0.02]
Stock X Laser	-0.01	[0.04]			0.03	[0.04]		
Custom X Laser	-0.14*	[0.05]			-0.12†	[0.05]		
Design X Laser	0.12	[0.08]			0.14‡	[0.08]		
Distributor X Laser	-0.33*	[0.06]			-0.31*	[0.06]		
Advertiser	-0.05*	[0.01]	-0.04*	[0.01]	-0.13*	[0.01]	-0.13*	[0.01]
Foreign	0.04*	[0.01]	0.05*	[0.01]	0.04*	[0.01]	0.04*	[0.01]
Integrated	0.23*	[0.02]	0.25*	[0.02]	0.17*	[0.02]	0.18*	[0.02]
Preexisting firm	-0.27*	[0.01]	-0.27*	[0.01]	-0.27*	[0.01]	-0.27*	[0.01]
Product age	0.03*	[0.00]	0.02*	[0.00]	0.02*	[0.00]	0.02*	[0.00]
N of firms in market	-0.00*	[0.00]	-0.00*	[0.00]	-0.00*	[0.00]	-0.00*	[0.00]
Stock X System			-0.03	[0.03]			-0.01	[0.03]
Custom X System			0.02	[0.03]			0.04	[0.03]
Design X System			0.03	[0.05]			0.03	[0.05]
Distributor X System			0	[0.05]			0.01	[0.05]
Constant	-1.57*	[0.03]	-1.58*	[0.03]	-1.49*	[0.03]	-1.50*	[0.03]
N	395,523		381,510		395,523		381,510	
Year FE	YES		YES		YES		YES	
Firm RE	YES		YES		YES		YES	
Wald Stat	3521*		3427*		3600*		3512*	
Log pseudolikelihood	-165148		-158972		-165102		-158921	

Firm-clustered standard errors in brackets; *p<0.01, † p<0.05, ‡ p<0.1

Table 11 Notes: The method of estimation is maximum likelihood (ML) for conditional RE complementary log-log regression. The dependent variable is a binary variable set to one in the year a firm exits the product market. The explanatory variables are described in the main text as well as in Table 2. See notes for Table 5 for additional notes.

Table 12. Impact of Product Customization on Number of Firms, Entrants and Exits at the Market Level

Column	34		35		36		37		38		39	
Sample	All Industries											
D.V.=	N Firms		N Entrants		N Exits		N Firms		N Entrants		N Exits	
Estimates	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se
MMC_1	-0.01	[0.01]	-0.01	[0.01]	-0.01	[0.01]						
MMC_2							0.24	[0.33]	0.06	[0.29]	0.27	[0.29]
L1.fStock	-0.75*	[0.12]	-0.71*	[0.11]	-0.60*	[0.11]	-0.74*	[0.13]	-0.70*	[0.11]	-0.58*	[0.11]
L1.fCustom	0.37*	[0.12]	0.18‡	[0.11]	0.05	[0.11]	0.35*	[0.12]	0.17	[0.11]	0.03	[0.11]
L1.fDesign	-0.1	[0.20]	-0.03	[0.16]	-0.02	[0.17]	-0.09	[0.19]	-0.01	[0.16]	0	[0.17]
L1.fDistributor	-0.17	[0.14]	-0.27†	[0.12]	-0.29†	[0.13]	-0.16	[0.14]	-0.25†	[0.12]	-0.29†	[0.13]
L1.fStock X Laser	0.41	[0.41]	0.73†	[0.33]	0.41	[0.29]	0.37	[0.41]	0.71†	[0.33]	0.37	[0.28]
L1.fCustom X Laser	-1.59*	[0.59]	-0.86‡	[0.49]	-1.28*	[0.41]	-1.56*	[0.59]	-0.85‡	[0.49]	-1.24*	[0.40]
L1.fDesign X Laser	-0.77	[0.90]	-1.01	[0.79]	-0.38	[0.69]	-0.76	[0.90]	-1.01	[0.79]	-0.38	[0.68]
L1.fDistributor X Laser	1.34	[0.84]	0.4	[0.66]	0.87	[0.65]	1.37	[0.85]	0.4	[0.66]	0.9	[0.66]
Constant	3.30*	[0.12]	1.12*	[0.10]	1.81*	[0.11]	3.23*	[0.14]	1.08*	[0.12]	1.72*	[0.13]
N	16,329		16,329		16,073		16,329		16,329		16,073	
Year FE	YES		YES		YES		YES		YES		YES	
Wald Stat	307.8		1381		580.5		309.8		1386		577.6	
Log likelihood	-66565		-36941		-37429		-66564		-36942		-37428	

Market-clustered standard errors in brackets; * p<0.01, † p<0.05, ‡ p<0.1

Table 12 Notes: The method of estimation is maximum likelihood for negative binomial regression. The dependent variables are N of Exits by market by year and N of Exits by firms that do not produce custom products. All explanatory variables are lagged by one period. The sample for estimations is drawn from the full sample of 19,329 Market-Year observations after excluding year 1997 and 2009 because the lagged values are missing for 1997 and exits are censored for 1999.