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The Moderating Role of Submarket Dynamics on the Product Customization–Firm Survival Relationship

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In this paper, we examine how the provision of product customization services affects firm survival. Integrating literatures on industry evolution, product-related adapting services, and entry deterrence, we hypothesize that the relationship between product customization—the costly modification of a product to cater to customer needs—and firm survival differs across industries, based on the extent of submarkets. We argue that in industries that feature submarkets more prominently, the positive association between product customization and firm survival is stronger for two conceptually distinct and empirically distinguishable mechanisms: customizing firms enter new submarkets and also deter potential entry. We conclude that offering product customization services has strategic benefits that sometimes outweigh the cost of coordinating with customers.

Keywords: competitive strategy; strategy and policy; longitudinal research design; industrial organization; evolutionary approaches; product design; technology and innovation management
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1. Introduction

Product-related services have become increasingly important for firms selling products across many industries, from automobiles to information technology (Cusumano 2008, Davies 2004, Wise and Baumgartner 1999). The growing importance of product-related services is reflected in the rising share of profits that product firms obtain from offering services (Cusumano 2010) and the associated improvements in product firms' operating margins and financial performance (Suarez et al. 2013, Fang et al. 2008). Many product-related services, such as financing, warranty, and maintenance, enable the sale and use of a product without significantly altering its functionality. In contrast, product customization services—termed *adapting services* by Cusumano et al. (2015)—significantly expand the functionality of a product by adapting it to novel conditions and helping customers develop new uses for it. They argue that adapting services tend to be tightly coupled with products and thus require more knowledge exchange between the product firm and its customers and that the resulting custom products are more competitive than generally available standalone products. Citing the growing importance of product-related services, Suarez et al. (2013) call for increased research on how such services affect firm growth and survival, as well as industry structure and evolution. We are unaware of any careful empirical analysis of the relationship between the provision of product customization services and firm survival and how factors such as industry characteristics moderate the relationship. Our paper attempts to address this gap in the literature on product-related services.

Prior studies suggest that product customization services can help firms' survival prospects. First, customization allows product firms to identify the emerging demand for novel user needs, and thus can create sustainable competitive advantage through technology choices (Adner and Zemsky 2006, Christensen 1997). Second, customization is associated with the presence of specific organizational units and processes (Attewell 1992) that facilitate effective interdepartmental coordination and organizational learning (Ahuja et al. 2013, Kotha 1995). Such coordination and learning are key to new product development at an organization, both internally (Adler 1995) and externally (Griffin and Hauser 1993, von Hippel 1986).

In this paper, we argue that the product customization–firm survival relationship is moderated by the extent to which an industry features *submarkets*. Often likened to independent islands of activity within an industry, submarkets reflect unique production technologies on the supply side *and* user applications on the demand side. Prior studies suggest that the patterns of arrival and destruction of submarkets within an industry, known as submarket dynamics, and *between-industry* heterogeneity in such patterns can explain the differences in firm survival across industries (Buenstorf and Klepper 2010, Klepper and Thompson 2006, Sutton 1998). For example, the proliferation of independent submarkets within an industry can delay the onset of a shakeout (Bhaskarabhatla and Klepper 2014), limit the profitability of unilateral escalation in R&D and advertising intensity (Sutton 1998), and moderate the relationship between firm behavior and performance (Gambardella and Giarratana 2013).

We hypothesize that the relationship between product customization and firm survival is *stronger* in industries featuring general-purpose technologies that give rise to submarkets more prominently. We further hypothesize that this relationship is stronger for two conceptually distinct and empirically distinguishable mechanisms. First, we argue that the need for custom solutions specific to several downstream uses is greater in industries featuring general-purpose technologies (Gambardella and McGahan 2010) and that customization through adapting services can boost firm survival in such industries by unlocking new opportunities. Second, customizing firms with better information about user needs in a submarket can deter subsequent entry through entering new submarkets and closing opportunities for others to enter (see Ahuja et al. 2013, McGahan 1993).

We test the proposed hypotheses using an unusually rich panel data set on products and product-related services for 13 closely related industries in the photonics sector. The select industries differ in terms of the general-purpose nature of their underlying technology and their capacity to feature submarkets. Among them, the laser industry features innumerable submarkets because of the wavelength specificity of its many applications (see, for details, Klepper and Sleeper 2005, Klepper and Thompson 2006). We empirically examine the proposed mechanisms that link product customization and firm survival, and we present consistent evidence.

The literature on the determinants of firm survival and industry evolution is vast and replete with *single-industry* case studies.[1] Some scholars have pooled disparate industries to examine the common determinants of firm survival across industries (Agarwal et al. 2002, Klepper 2002b, Suarez and Utterback 1995). Single-industry case studies and their pooled sample studies allow for a deeper understanding of the organizational outcomes within specific industries over the product life cycle (Klepper 1997). Yet industries differ vastly. Prior studies attribute nearly half of the variance in firm profitability to industry- and segment-specific factors (McGahan 1999, McGahan and Porter 1997). Furthermore, the performance of the average firm in an industry is largely determined by industry characteristics (Hawawini et al. 2003).[2] Unlike previous studies that employ a single industry, we exploit between-industry heterogeneity in submarket dynamics to explain systematic industry-level differences in firm survival.

Our study contributes along several dimensions. First, it contributes to the empirical literature on the impact of product-related adapting services on firm survival (Suarez et al. 2013). Second, we extend the submarkets-based theory of industry evolution by testing the moderating role of submarket dynamics in the relationship between product customization and firm survival at various levels of analysis (Young et al. 1996, Rousseau 1985). Third, our study contributes to the strategy literature that examines how multiproduct firms can leverage users to develop custom solutions and deter entry (McGahan 1993). While prior studies highlight the role of users in product innovation (Chatterji and Fabrizio 2012), our results suggest that firms can undertake product customization services when the strategic benefits of entry deterrence outweigh the costs of contracting with users who possess sticky information about their preferences (von Hippel 1998). Finally, our study adds to the limited empirical literature on the evolution of populations of vertically related industries (de Figueiredo and Silverman 2007) and shows how the intensity of submarket activity can lead to significant differences in organizational outcomes across industries.

The remainder of the paper is organized as follows. In Section 2, we review the literature on product customization and firm survival and the role of submarket dynamics. In Section 3, we describe the industry context and data for the study. In Section 4, we elaborate on our estimation strategy. We present econometric evidence in Section 5 and conclude in Section 6 with a discussion of our study's contribution and limitations.

2. Theoretical Framework and Hypotheses

2.1. Adapting Services of Product Firms with General-Purpose Technologies

Industries differ in the nature of their underlying technology, which leads to differences in their market structure (Sutton 1998). In many industries that feature a dedicated technology for a specific downstream application, product customization leads primarily to product personalization. Firms in several such industries—from automobiles and consumer electronics to clothing and website design— "listen" to customer needs and offer customization services (Urban and Hauser 2004, Dellaert and Stremersch 2005, Bayus 2008). The personalization of products may lower a customer's reluctance to buy and increase her willingness to pay, but it does not necessarily appeal to a new market niche or change the dominant use of the product.

Yet in some industries, particularly those characterized by general-purpose technologies, products can be customized for several downstream applications, each associated with a novel market opportunity. For example, computers are considered a general-purpose technology, as they are found in applications across several sectors ranging from medical diagnostics to financial services (Bresnahan and Greenstein 1999). Gambardella and McGahan (2010, p. 269) note that in industries featuring general-purpose technologies, product customization becomes central to firm growth and survival:

> Ideas hinge on more basic scientific and technological knowledge that make the underlying technologies more

> general and abstract with respect to specific applications. Thus security software and new, simulation-generated drug compounds are based more on theories about applicability than on customer-defined problems, and so the underlying technologies are not only inherently more general in nature because the initial spark of technological insight is theoretical, but also less clearly associated with specific individual applications. This allows innovators a broader market of potential opportunities for customization (and thus a broader set of opportunities to capture value).

Despite the promise, firms in industries featuring general-purpose technologies face considerable challenges in commercializing their technology (Gambardella and McGahan 2010) and undertake product customization activity to enter new submarkets. The qualitative literature documents cases of firms that transform general-purpose technologies into multiple products for independent applications by adopting a commercialization strategy that emphasizes the advantages of product-customization services (Thoma 2009, Maine and Garsney 2006). In what follows, we examine the broader literature on the relationship between the provision of adapting services, as conceptualized by Cusumano et al. (2015), and firm survival to develop hypotheses about how submarket dynamics affect that relationship.

2.2. Product Customization and Firm Survival

Previous studies suggest that product customization has several benefits. First, customization increases customer preference fit for a product (Franke et al. 2009), which in turn increases customer valuation (Franke et al. 2010, Syam et al. 2005). Although it is challenging to elicit and incorporate customer preferences and their optimal order (Levav et al. 2010, von Hippel 1986), the advent of the Internet has made the process cheaper (Ansari and Mela 2003). Recent evidence suggests that involving the customer in collaborative prototyping (Terwiesch and Loch 2004) and offering customizable *starting solutions* increase customer valuation (Hildebrand et al. 2014, Alexandrov 2008). Consequently, customization is associated with greater customer loyalty and lock-in (Murthi and Sarkar 2003) and lower service costs (Kumar and Telang 2011).

Second, existing theoretical models show that the presence of custom products allows firms, under certain conditions, to charge higher prices for their standard products. Firms with customized products sell to customers dissatisfied with standard products without having to subsidize those who buy the standard products (Syam and Kumar 2006). Product customization is also associated with an overall increase in industry profits because of product differentiation and softening competition (Bernhardt et al. 2007).

Third, at the organizational level, customization services lead to organizational learning and innovation. Firms that provide product-customization services gain a deeper understanding of the emerging demand for user needs and the use of custom products, which can be leveraged in new technology development (Adner and Zemsky 2006, Christensen and Rosenbloom 1995, Habermeier 1990). Such learning allows a firm that customizes to redeploy resources and transfer prior experience in developing custom products into a new market (Chen et al. 2012, King and Tucci 2002). Customization activities are associated with the presence of specific organizational units, sometimes referred to as service bureaus (Attewell 1992). They facilitate effective interdepartmental coordination—seen as crucial to new product development—both internally (Adler 1995, Kotha 1995) and externally (Griffin and Hauser 1993, von Hippel 1986). For example, Kotha (1995) documents a Japanese bicycle manufacturer's organizational processes to learn from and train its best production workers. Such service bureaus act as repositories of organizational learning associated with product-related services and agents of technology diffusion in an industry.

Fourth, by changing organizational resource allocation and staffing, product-customization services strengthen the appropriability regime governing future inventions based on a firm's existing technology. Ahuja et al. (2013) argue that the underlying invention for each product has a conceptual component, which has the potential for adaptation to new contexts and for reuse. They distinguish between primary appropriability, which captures "the effectiveness in exploiting inventions as problem-solving mechanisms and capturing a share of their profits," and generative appropriability, which captures "the effectiveness in exploiting inventions as concepts and capturing a share of the future inventions they spawn" (Ahuja et al. 2013, p. 248). They argue that focusing on strengthening generative appropriability forces firms to pay attention to customer needs:

> Enhancing generative appropriability pushes attention toward inventiveness and requires thinking about how different groups of potential users might find the principle underlying the invention useful, or thinking about how that principle may be used to respond to other needs.
> (Ahuja et al. 2013, p. 251).

We argue that firms that establish organizational units to provide product-related customization services enhance their generative appropriability and better capture value from emerging user needs. Building on the above extensive literature on the performance benefits of product customization, we propose the following hypothesis.

Hypothesis 1 (H1). *Product customization services are positively related to firm survival.*

2.3. Submarket Dynamics and the Product Customization–Firm Survival Relationship

Next, we examine how the benefits of offering product customization services vary across industries. While industries differ along several dimensions, we focus on the extent of submarkets, as the theoretical literature suggests that submarket activity can provide a parsimonious explanation for such differences in firm survival and industry evolution (Klepper and Thompson 2006). We argue that submarket dynamics—the pattern of arrival and destruction of submarkets within an industry—can explain the between-industry differences in the strength of the relationship between product customization and firm survival. In industries that feature submarkets prominently, product customization involves repeated interactions with users in downstream submarkets. These interactions result in the acquisition of unique submarket-specific technological knowledge and capabilities that become a source of competitive advantage. Building on Franco et al. (2009), we argue that such sustained technological capabilities increase the likelihood of firm survival more in submarket-rich industries. Product customization also allows firms in such industries to leverage their technological capabilities through innovative business models that address the needs of several downstream submarkets and extract rents from downstream users through separate licensing agreements (Gambardella and Giarratana 2013, Gambardella and McGahan 2010). Product customization also confers greater benefits from paying attention to emerging user needs in submarket-rich industries by strengthening generative appropriability (Ahuja et al. 2013).

Klepper and Thompson (2006) develop a model of industry evolution that allows for examination of the relative rates of firm survival across industries with differing levels of independent submarkets. In their model, the generality of an industry is captured by the rate at which new submarkets arise, and all firms are equally likely to discover a new opportunity, regardless of their engagement with customers. Following Cusumano et al. (2015), we argue that firms that offer product-customization services are more likely to enter new submarkets and capture greater value from them than those that do not (Ahuja et al. 2013, Gambardella and Giarratana 2013). Consequently, firms that offer product-customization services become, on average, less likely than other firms to exit the industry. Furthermore, we expect the impact of product customization on firm survival to be stronger in industries with higher submarket potential, as customizing firms enter more submarkets and capture a greater share of the value. Therefore, we propose the following hypothesis.

HYPOTHESIS 2 (H2). *Pioneering effect*: *The positive effect of product customization on firm survival is stronger in industries with a higher submarket potential relative to other industries.*

2.4. Entry Deterrence and the Product Customization–Firm Survival Relationship

We examine the strategic aspects of offering product-customization services. The existing theoretical literature identifies several strategic motives for product customization. One view is that the provision of customization services is a costly signal of firm quality. In a market composed of firms with varying abilities that customers cannot fully observe, firms with higher abilities offer custom prototypes below cost to signal their capability (Terwiesch and Loch 2004). Extending this view, Mendelson and Parlaktürk (2008) argue that high-ability incumbents offering custom prototypes for a low price can deter entry.

A complementary view is that the provision of customization services leads to a proliferation of the product variety. It is well established that incumbent firms can credibly precommit to overinvesting in product variety, capacity, or advertising to deter entry (see, for a review, Tirole 1997). Building on this view, Dewan et al. (2003) argue that overinvestment in product customization can also deter entry. In their theoretical model, an incumbent monopolist under the threat of potential entry by a second-mover chooses a level of customization to deter entry, which serves as a credible precommitment signal to potential entrants. Dewan et al. (2003) find that an incumbent's ability to deter entry increases as both the cost of entry into a market and the reservation price for the custom variety increase. In other words, if customization of a product can lead to a large submarket (such as lasers for eye surgery), the reservation price for prototyping such products would be higher, leading to greater entry deterrence.

Incumbents in general have weaker incentives to innovate, given their legacy sources of revenue, if they are not exposed to actual or potential competition (Tirole 1997, Arrow 1962). However, to the extent that incumbents pioneer new and independent submarkets that do not cannibalize the existing sources of revenue, they have as much, if not more, incentive to innovate as potential entrants. Yet not all incumbents pay close attention to emerging customer needs. Prior studies show that incumbents often focus heavily on existing markets and higher technical performance and neglect subtle changes in customer preferences, which can lead to new market opportunities (Christensen 1997). We argue that incumbents that provide adapting services for product customization are more likely than other incumbents to enter and exploit new market opportunities and that their presence has a deterrent effect on entry. Strengthening this view is McGahan (1993), who shows that incumbents with superior information about demand and customer preferences deter entry regardless of the other preemption strategies they may employ. A potential entrant is discouraged from entry if it cannot learn about customer needs until after entry and if it believes that the incumbents have an informational advantage concerning demand.

Similarly, Ahuja et al. (2013) argue that generative appropriability that results from product customization has a *preclusive* component that deters entry. Firms that provide product customization services are more effective in preventing others from building inventions based on their own inventions. Building on the above literature, we argue that the greater the number of firms that provide product customization services in a market, the greater the deterrent effect is. Thus, we propose the following hypothesis.

HYPOTHESIS 3 (H3). *Deterrence effect*: *A greater fraction of firms undertaking product customization services in period $t-1$ is associated with a lower extent of entry and incumbent exits in period t.*

The deterrent effect associated with product customization has not been modeled in the theoretical literature on submarkets. In the Klepper-Thompson submarkets model, incumbents may be assumed to have a higher probability of entering newly created submarkets if they already have more submarkets. But the additional survival premium reflects submarket pioneering rather than entry deterrence, which Ahuja et al. (2013) term the *cumulative* component. The survival premium from deterrence derives from incumbents' increased market power and the softening of competition resulting from a *decrease in net entry* into the submarket (Loginova 2012, Polidoro and Toh 2011).

So how does the survival premium from entry deterrence differ across industries? The incentive for incumbents to invest in product-customization services is higher in industries that feature submarkets more prominently, as they stand to benefit more (Ahuja et al. 2013). Such an investment, as we argued earlier, is a vehicle for strategic entry deterrence. Consequently, in industries with greater submarket potential, product customization can be a stronger deterrent to potential entrants. Furthermore, in such industries, incumbents gain greater product customization experience and organizational learning, which reinforces their informational advantage over potential entrants (McGahan 1993). While not all incumbents provide customization services, to the extent that incumbents that do provide customization have an informational advantage, their presence in greater numbers is expected to deter entry more strongly in industries with higher submarket potential. Building on the above reasoning, we propose the following hypothesis.

HYPOTHESIS 4 (H4). *The deterrence effect on firm entry and incumbent exits is stronger in industries with higher submarket potential than in other industries.*

3. The Research Context and Data

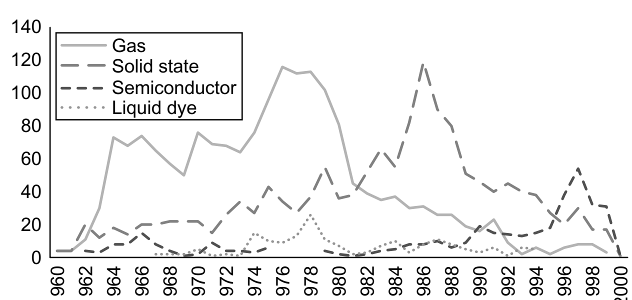
3.1. The Upstream Laser and Related Industries

We test our hypotheses using the set of industries in the photonics sector because one of the industries—the upstream laser industry—is particularly suited for the study of submarket dynamics since it features a general-purpose technology. Considerable debate exists over the definition of general-purpose technologies and which industries feature them. Lipsey et al. (1998, 2005) consider a number of potential candidate industries and determine that lasers, among other things, are a general-purpose technology with many underlying applications (see, for another application, Breschi et al. 2010). In examining the upstream laser industry, Klepper and Sleeper (2005) find that laser firms often produce multiple types of lasers that are used for widely differing applications, reflective of the generality of the underlying technology. The upstream laser industry also provides a context closest to the stylized model of independent submarkets, as (Klepper and Thompson 2006, p. 870) note:

> Submarkets can occur at many levels, but in lasers it is useful to think of them as corresponding to particular applications serviced by specific lasers. Lasers differ with regard to their power and the wavelength of light they emit, which constrains the applications for which they can be used. For example, very different lasers are required for scanning, for eye surgery, and for the working of metal. Consequently, the laser market can be thought of as being composed of submarkets with little if any relationship on the demand side, consistent with our model.

Pioneering new uses of lasers through product customization is common in the laser industry. With their invention in 1960, lasers' promise was considerable, and yet no dominant application was ever developed, prompting some industry observers to describe lasers as a solution looking for problems to solve. Over time, thousands of new lasers have been developed for various niche applications. Figure 1, based on Weber (2000),

Figure 1 ***N* of Scientific Articles Reporting New Laser Discoveries over Four Decades by Technology**



Note. Figure 1 is constructed by the authors based on the list of references in Weber (2000)—a comprehensive compilation of scientific articles reporting the discovery of new lasers—by technological trajectory.

depicts waves of new lasers entering the industry and opening up new opportunities, initially among gaseous lasing materials and subsequently in solid-state crystal and diode lasing materials.

While customization does not necessarily result in the creation of new submarkets, it is relatively more likely to occur in the upstream laser industry for reasons specific to the nature of the laser technology (see, also, Bhaskarabhatla and Klepper 2014). Aculight's development of laser-based hearing aids exemplifies this point. While traditional hearing aids use electrical signals to stimulate auditory nerves, laser-based hearing aids, which did not exist a decade ago, use optical signals. A laboratory at Vanderbilt University discovered the characteristics of laser light suitable for hearing aids. The head of business development at Aculight noted in an interview,

> They 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. (Optics.org 2007)

Aculight later pioneered a new submarket for infrared nerve stimulators and marketed them to several research organizations.

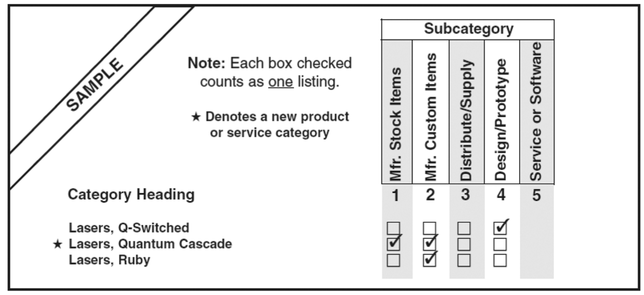
To meet the challenge of developing new uses, laser firms established organizational units called *application laboratories* or *system engineering groups* (Laser Focus 1970–1984), reminiscent of the service bureaus described by Attewell (1992). The leading laser firm, Coherent, established in 1966, pioneered various industrial uses of lasers in its application lab, as documented extensively by its engineers (Saunders and Bellis 1980). The proliferation of several types of lasers over time and their associated submarkets with specific applications make lasers the ideal context in which to test our hypotheses.

3.2. Photonics Spectra Data

Previous studies of the laser industry use Laser Focus buyers' guides (Klepper and Sleeper 2005, Klepper and Thompson 2006, Bhaskarabhatla and Klepper 2014), which do not capture the extent of product customization activity. We use data compiled from Photonics Spectra buyers' guides from 1997 to 2009. The data are based on a comprehensive annual survey of firms across 13 industries in the photonics sector. The survey instrument is flexible and allows for the creation of new product categories by survey respondents. Before publication, the editorial staff at Photonics Spectra verifies the survey responses against product manuals, thus ensuring highly accurate and reliable data.

Figure 2 shows a snippet of the survey asking firms whether—for each of their products—they manufacture standard versions of the product; provide customization services to meet user needs; undertake design and prototype activities; and serve as distributors or suppliers. 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. For example, as Figure 2 shows, the quantum cascade laser, a newly discovered diode laser, has been added to the questionnaire. The firm shown in Figure 2 designs and prototypes the Q-Switched laser, produces both stock and custom versions of the newly discovered quantum cascade laser, and produces only custom versions of the ruby crystal laser.

Figure 2 Questionnaire of Photonics Spectra Buyers' Guide



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 as well as custom products.

The 13-year panel data set, described in Table 1, contains 1,705 products and 8,970 U.S. and foreign firms. The upstream laser industry is composed of 80 (4.7%) products and 15,353 (3.6%) of the 428,471 firm-product-year observations. The downstream laser system industry accounts for 114 products and 29,190 observations.

4. Measurement and Estimation Strategy

4.1. Measuring Submarkets and Submarket Potential

Following the empirical literature (see Klepper and Sleeper 2005, Klepper and Thompson 2006, Bhaskarabhatla and Klepper 2014), we operationalize submarkets in an industry using the number of product markets as defined in Photonics Spectra. Admittedly, this operationalization provides empirical convenience rather than conceptual fit. As Klepper and Thompson (2006) recognize, defining submarkets using lasing material is not entirely accurate because independent submarkets can coexist within the market for the same material. For example, within the market for excimer gas lasers, at least two independent submarkets exist, one for producing semiconductor lithographic equipment and the other for performing laser-based eye surgery. However, Klepper and Thompson (2006, Endnote 13) note that

Table 1 Industries in Photonics Spectra Buyers' Guide

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

Notes. Table 1 lists the 13 vertically related industries in the photonics sector, with a particular focus on the upstream laser device and downstream laser system industries. The publishers of Photonics Spectra Buyers' Guide classify the industries.

while product markets defined according to laser types are broader than submarkets, most of the predictions of their model pertain to both, as long as submarkets are distributed randomly across product markets. Therefore, our empirical results hold if this assumption holds. Regardless of whether the assumption holds in our setting, we control for the potential nonrandom allocation of submarkets to product markets by controlling for product market fixed effects, which mitigates the measurement error.

The literature on submarkets and industry evolution argues that the nature of technology can determine an industry's submarket potential. For example, Sutton (1998) identifies flowmeters as an industry with high submarket potential and color film as an industry with low submarket potential. Building on this literature, we measure submarket potential using a dummy set equal to 1 for the laser industry and 0 otherwise. We argue that the upstream laser industry has greater submarket potential, given that it features a general-purpose technology with wide-ranging applications. An alternative is to develop a continuous measure of generality of industries based on the diversity of downstream applications, although such an operationalization is not possible using our data.[3]

4.2. Estimation Strategy

We employ two classes of models in our estimation. For survival analyses, following Franco et al. (2009), we use a firm-product-year observation structure with complementary log-log specification, which allows us to recover continuous-time hazard rates from our annual data. This formulation also 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 there is no sufficient statistic allowing fixed effects to be conditioned out of the likelihood, and incorporating unconditional fixed-effects estimates with the use of firm dummies results in biased estimates. Therefore, we report results using the linear probability model (ordinary least squares with a binary dependent variable), which is unbiased even if firm fixed effects are included. The full specification is as follows:

$$\begin{aligned} P(Exit)_{ijt} = {} & \alpha + \beta \cdot Custom_{ijt} + \gamma \cdot Custom_{ijt} \cdot Laser_{ijt} \\ & + \theta_i \cdot 1(Firm_i) + \delta_j \cdot 1(Product_j) \\ & + \kappa_t \cdot 1(Year_t) + \mathbf{X}\boldsymbol{\omega} + \epsilon_{ijt}, \end{aligned} \tag{1}$$

where i indexes firm, j product, and t year, and $\mathbf{X}$ is a vector of covariates. The dependent variable $P(Exit)$ is a dummy variable set equal to 1 if firm i exits product market j in year t, and 0 otherwise. The variable is set equal to 0 for the last year in our data, 2009, since we do not observe firm exits for that year. The coefficient β captures the increase in firm survival associated with the provision of product customization services in our data set across all products and over time. The coefficient of the interaction term γ captures the additional firm survival associated with customization in the laser industry relative to the other industries. Firm, product, and year fixed effects are included in the model.

At the product market level, we estimate models predicting the number of entrants and exits. Since these models involve count-dependent variables, all of which have shown overdispersion, we estimate negative binomial regressions for the following specification:

$$\begin{aligned} & Entrants_{jt}(or)Exits_{jt} \\ & \quad = \alpha + \beta \cdot Fraction\ of\ Custom_{jt-1} \\ & \quad + \gamma \cdot Fraction\ of\ Custom_{jt} \cdot Laser_{jt-1} \\ & \quad + \delta_j \cdot 1(Product_j) + \kappa_t \cdot 1(Year_t) + \mathbf{X}\boldsymbol{\omega} + \epsilon_{jt}, \end{aligned} \tag{2}$$

where *Fraction of Custom*$_{jt-1}$ is the fraction of firms in product market j in year $t-1$ that undertake product-customization services. The coefficient of the interaction term γ captures the additional change in entry and exit rates associated with undertaking customization services in the upstream laser device industry relative to other industries.

Identification

Our identification strategy relies on exploiting between-industry and between-firm variation in the self-reported measure for the provision of product-customization services. The measure is endogenous, in the sense that better firms are more likely to provide customization services (Mendelson and Parlaktürk 2008, Terwiesch and Loch 2004). One may argue that such firms survive longer in a submarket not because of customization, but because of superior firm quality. In addition, firms may differ in the quality of their customization services, which may, in turn, be systematically correlated with unobserved firm quality (von Hippel 1998). By exploiting the longitudinal nature of the data, we control for—albeit imperfectly—the firm-specific, time-invariant part of the unobservables, such as firm quality, which gives rise to endogeneity. The use of one-period lagged values for explanatory variables also partially mitigates endogeneity concerns. To control for local competition and its effect on customization (see Hsu et al. 2014), we include a dummy for California, which accounts for nearly 25% of the observations in our data. To isolate the survival effect of product customization from that arising from mutual familiarity and coordination among incumbents, we include a count measure of multimarket contact, which is the average of the number of times a firm meets rivals of the focal product market in nonfocal product markets in a given year (Gimeno and Woo 1996). We also control for additional firm- and product-specific factors to address the omitted variable bias. Since the data are a census of firms in each of the industries, our estimations do not suffer from selection bias. To further establish the robustness of the proposed hypotheses, we test whether similar relationships are observed in our data if we remove observations specific to the upstream laser device industry and treat the downstream laser system industry as the one featuring submarkets prominently.

Additional Control Variables

Table 2 contains a brief description of the control variables. In addition to *custom*, we control for the three variables that relate to a firm's production activities: *stock*, *design*, and *distributor*. Each is a dummy variable set equal to 1 if the firm reports undertaking the associated activity in a product market in a year. For example, if, in a given year, a firm reports manufacturing stock products, which are prebuilt products for generic purposes, then the measure *stock* is set equal to 1, and 0 otherwise. The variable *design* measures whether a firm engages in design and prototype activity. The *distributor* dummy identifies firms that distribute and supply products. These measures are not mutually exclusive in the survey, and firms may report undertaking multiple activities in a given year within a product market.

Additional control variables include the following: *advertiser*, a dummy for whether a firm pays Photonics Spectra an 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 data set in 1997; *product age*, a time-varying, product-specific clock starting in 1997; *N of firms*, a variable measuring the number of firms in a product market in a year; *firm scope*, a variable measuring the

Table 2 Description of Variables

Variable	Description
Market exit	= 1 if a firm exits a market in a year and 0 otherwise
Stock, custom, design, distributor	= 1 if a firm reports providing stock products or customization, design, or distributor services for a product in a market and 0 otherwise
Fraction of stock, fraction of custom, fraction of design, fraction of distributor	Fraction of firms in a market in a year that undertake the production of stock, custom, design, or distribute products
Foreign	= 1 if a firm is non-U.S.-based and 0 otherwise
Foreign, advertiser	= 1 if a firm is an advertiser and 0 otherwise
Preexisting firm	= 1 if a firm is present in a market in 1997 (the year our data set begins) and 0 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, 1997 for preexisting markets
Firm scope	Measures the number of distinct markets in which a firm is active in a year in the laser industry
Vertical integration	= 1 if a firm produces a laser and a laser-based system in a month and 0 otherwise
Multimarket contact	The average of the number of times a firm is present with rivals of the focal market in nonfocal markets in a given year at the firm level
Log*(Employees)*	Log of employees, which is a measure of firm size
California dummy	= 1 if a firm is located in California

Table 3 Summary Statistics for Variables in the Data for Samples Used in Estimations

Sample (N)	All industries ($N = 428{,}471$)				Upstream laser industry ($N = 15{,}353$)			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Market exit	0.14	0.35	0	1	0.15	0.36	0	1
Stock	0.48	0.50	0	1	0.57	0.50	0	1
Custom	0.42	0.49	0	1	0.33	0.47	0	1
Distributor	0.18	0.39	0	1	0.26	0.44	0	1
Design	0.14	0.35	0	1	0.11	0.31	0	1
Advertiser	0.29	0.46	0	1	0.29	0.45	0	1
Foreign	0.25	0.43	0	1	0.44	0.50	0	1
Integrated	0.12	0.33	0	1	0.70	0.46	0	1
Preexisting firm	0.46	0.50	0	1	0.36	0.48	0	1
Product age	5.79	3.69	0	12	5.87	3.66	0	12
N firms	47.00	37.55	2	195	46.99	40.51	2	131
Firm scope	21.83	38.82	1	329	22.14	40.46	1	329
Multimarket contact	2.19	3.29	0	120	1.92	2.05	0	24
Log*(Employees)*	3.03	1.87	0	11.98	3.06	1.89	0	10.00
California dummy	0.18	0.38	0	1	0.19	0.39	0	1

number of product markets in which a firm is present in a given year in our data set; log(*employees*), a measure of firm size; and *California dummy*, an indicator variable for firms located in California.

5. Results

5.1. Descriptive Statistics

Descriptive statistics for the overall sample and the upstream laser industry subsample are shown in Table 3. The average number of firm—product–year observations that comprise firm exits from product markets in a given year is 14%–15% in both the overall sample and the laser subsample. The probability of producing a stock product is 42% in the overall sample, while it is higher in the laser industry, at 57%. In contrast, the number of firm—product–year observations with product-customization services is lower in the subsample of lasers: 33% versus 42% overall. Advertising activity is similar in the laser and related industries, at 29%. 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 similar: 46 firms per product market.

Pairwise correlations among variables in the data set are shown in Table 4. The correlation between the probability of exit and custom is −0.02, reflecting a weak unconditional relationship between firm exit and product-customization services. The correlation of 0.13 between *stock* and log(*employees*) suggests that firms that produce stock products are more likely to be large. Similarly, the correlation between *custom* and *multimarket contact* is 0.14, reflecting that firms that engage in customization are also likely to have greater multimarket contact. In addition, there are positive, albeit low, correlations among measures of *firm scope*, *multimarket contact*, *advertising*, and *integration*.

Table 4 Pairwise Correlations Among Variables

Variable	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Market exit	1	1.00													
Stock	2	−0.01	1.00												
Custom	3	−0.02	−0.20	1.00											
Distributor	4	0.01	−0.38	−0.32	1.00										
Design	5	0.01	−0.16	−0.02	−0.11	1.00									
Advertiser	6	−0.02	0.05	0.17	−0.12	0.00†	1.00								
Foreign	7	0.02	−0.07	−0.05	0.09	−0.03	−0.17	1.00							
Integrated	8	0.03	0.08	−0.06	0.04	−0.05	0.14	0.08	1.00						
Preexisting firm	9	−0.06	0.05	0.02	−0.04	−0.01	0.02	−0.12	−0.04	1.00					
Product age	10	−0.05	−0.03	0.02	−0.03	−0.01	0.01	0.04	0.00†	−0.34	1.00				
N firms	11	−0.02	−0.12	0.07	−0.04	0.07	0.03	0.01	−0.02	0.03	0.04	1.00			
Firm scope	12	0.02	0.08	0.00	−0.06	−0.01	0.44	−0.10	0.41	0.00†	−0.02	−0.01	1.00		
Multimarket contact	13	−0.01	0.04	0.14	−0.11	−0.05	0.46	−0.11	0.23	0.04	−0.03	0.01	0.68	1.00	
Log(*Employees*)	14	0.03	0.13	0.08	−0.12	−0.06	0.13	0.05	0.09	0.07	−0.03	−0.03	0.20	0.15	1.00
California dummy	15	0.00	0.03	0.00†	−0.06	0.01	0.05	−0.27	0.06	0.02	−0.01	0.00†	0.14	0.10	−0.02

Note. $N = 428{,}471$. †Not significant at $p = 0.1$.

5.2. Product Customization and Market Pioneering Across Industries

We begin by estimating Equation (1) using the full sample. Table 5 contains the results for the impact of product customization on the probability of a firm exiting the product market. In column 1, the coefficient estimate of *custom* is negative and significant, reflecting a 12.2% $(= \exp(-0.13) - 1)$ lower probability of exiting a product market in the overall sample, consistent with our Hypothesis H1. 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 the 11.3% additional decline in the probability of exit in the laser industry, consistent with our Hypothesis H2. In column 2, we remove observations for the laser industry from the overall sample and estimate the survival premium from customization for laser system producers. The coefficient estimate of *Custom* × *System* is 0.04 and not significant at the 0.1 level, indicating no additional survival premium in the downstream laser system industry relative to the average survival premium from customization of 10.4%. It may be argued that we do not control for firm-specific, time-invariant unobserved heterogeneity in columns 1 and 2. To address this concern, we include firm fixed effects and estimate linear probability models in columns 3 and 4 and obtain qualitatively similar results.

These results are robust to the inclusion of several control variables, such as *stock*, *design*, and *distributor*. The coefficient estimates for *stock* and *distributor*

Table 5 Probability of Market Exit as a Function of Providing Product Customization Service

Column no.	1		2		3		4	
Estimation method	ML for complementary log–log				Ordinary least squares			
Estimation sample	All industries		Except laser		All industries		Except laser	
D.V. = P[*Market exit*]	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Stock	−0.12*	[0.01]	−0.12*	[0.01]	−0.03*	[0.00]	−0.03*	[0.00]
Custom [H1]	**−0.13***	**[0.01]**	**−0.12***	**[0.01]**	**−0.02***	**[0.00]**	**−0.02***	**[0.00]**
Distributor	−0.03‡	[0.02]	−0.02	[0.02]	−0.01†	[0.00]	−0.01*	[0.00]
Design	0.00	[0.02]	0.00	[0.02]	−0.01*	[0.00]	−0.01*	[0.00]
Stock × *Laser*	0.05	[0.04]			−0.04*	[0.01]		
Custom × *Laser* [H2]	**−0.12**†	**[0.05]**			**−0.02***	**[0.01]**		
Design × *Laser*	0.18†	[0.08]			0.00	[0.01]		
Distributor × *Laser*	−0.28*	[0.06]			−0.03*	[0.01]		
Stock × *System*			0.00	[0.03]			−0.02*	[0.00]
Custom × *System*			**0.04**	**[0.03]**			**0.00**	**[0.00]**
Design × *System*			0.03	[0.05]			0.00	[0.01]
Distributor × *System*			0.03	[0.05]			−0.01	[0.01]
Advertiser	−0.11*	[0.01]	−0.11*	[0.01]	0.03*	[0.00]	0.03*	[0.00]
Foreign	0.04*	[0.01]	0.04*	[0.01]	−0.03*	[0.00]	−0.03*	[0.00]
Integrated	0.11*	[0.02]	0.09*	[0.02]	−0.01†	[0.00]	−0.01†	[0.00]
Preexisting firm	−0.28*	[0.01]	−0.28*	[0.01]	0.01*	[0.00]	0.01*	[0.00]
Product age	0.03*	[0.00]	0.02*	[0.00]	0.01	[0.01]	0.01	[0.01]
N of firms in market	−0.00*	[0.00]	−0.00*	[0.00]	0.00*	[0.00]	0.00*	[0.00]
Firm scope	0.00*	[0.00]	0.00*	[0.00]	0.00*	[0.00]	0.00*	[0.00]
Multimarket contact	−0.04*	[0.00]	−0.04*	[0.00]	−0.01*	[0.00]	−0.01*	[0.00]
Log(*Employees*)	0.05*	[0.00]	0.05*	[0.00]	−0.00†	[0.00]	−0.00†	[0.00]
California dummy	0.05*	[0.01]	0.05*	[0.01]	−0.01*	[0.01]	−0.02*	[0.01]
Constant	−1.73*	[0.03]	−1.75*	[0.03]	0.00	[0.02]	0.00	[0.02]
Observations	394,913		380,962		427,788		413,118	
Year FE	YES		YES		YES		YES	
Firm-market RE	YES		YES					
Firm FE					YES		YES	
Market FE					YES		YES	
Log pseudolikelihood	−164,473		−158,315					
R^2					0.289		0.289	

Notes. The method of estimation is maximum likelihood (ML) for conditional random effects (RE) complementary log-log regression in columns 1 and 2 and OLS in 3 and 4. The full sample, used in columns 1 and 3, contains 1,705 product markets spanning 13 industries in the Photonics Spectra Buyers' Guide, including upstream laser devices and downstream laser systems industries. 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 1 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, as well as in Table 2.

Coefficient estimates related to the hypotheses are shown in bold face; firm-clustered standard errors in brackets; $^*p < 0.01$, $^\dagger p < 0.05$, $^\ddagger p < 0.1$.

are negative and significant in columns 1–4. Distributors in our data set do not generally manufacture their own products but, rather, serve as intermediaries, particularly for foreign laser firms, which explains their longevity. The coefficient estimate of *design* is not significant in many regressions. One reason is that the survey identifies a small number of laser scientists and laser consultants as firms that design lasers. Notwithstanding these controls, one might argue that our results are driven by the behavior of some of the "outlier" industries, such as optical equipment and testing equipment, featuring far more product markets than lasers. To examine this, we exclude these two industries and estimate Equation (1). We find qualitatively similar results; for brevity's sake we do not report them.

5.3. Product Customization and Entry Deterrence Across Industries

Next, we investigate the role of product customization on entry and exit at the product market level. The results of Equation (2) for entry are shown in Table 6. In column 5, the coefficient estimate of *Fraction of custom* is positive and significant at the 0.1 level, which is not consistent with Hypothesis H3. However, the coefficient estimate *Fraction of custom* × *Laser* is negative and significant at the 0.1 level and larger than the main effect of *Fraction of custom*, thus reflecting the deterrent effect of product customization in the laser industry, consistent with Hypothesis H4. However, in column 6, the coefficient estimate of *Fraction of custom* × *System* is small in magnitude and not statistically significant, suggesting that the deterrent effect is prominent only in the upstream laser industry. We include panel fixed effects in columns 7 and 8 and obtain broadly similar results.

Finally, we examine the impact of the intensity of product customization on the number of exits. We again estimate Equation (2) with the number of exits as the dependent variable and present the results in Table 7. In column 9, the coefficient estimate of *Fraction of custom* × *Laser* is negative and significant and larger than the main effect of *Fraction of custom*, indicating fewer exits in the laser industry as the fraction of firms that undertake customization increases, consistent with Hypothesis H4. The effect is prominent in the upstream laser industry but not in the system industry, as the estimates in column 10 show. We include market fixed effects and obtain broadly similar results. The coefficient estimate of *Fraction of custom* × *Laser* is large, negative, and significant in column 11, but the coefficient estimate of *Fraction of custom* × *System* is insignificant in column 12, reflecting the deterrent effect specific to the laser industry.

Table 6 Estimates of Product Customization and Number of Entrants at the Product Market Level

Column no.	5		6		7		8	
Estimation method	Negative binomial, pooled				Negative binomial, panel fix effects (FE)			
Estimation sample	All industries		Excluding lasers		All industries		Excluding lasers	
D.V. = *Entrants*	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Fraction of stock	−0.71*	[0.11]	−0.71*	[0.11]	1.93*	[0.06]	1.90*	[0.06]
Fraction of custom [H3]	0.18‡	[0.11]	0.13	[0.11]	1.62*	[0.06]	1.64*	[0.06]
Fraction of design	−0.03	[0.16]	−0.05	[0.17]	1.03*	[0.08]	1.06*	[0.08]
Fraction of distributor	−0.27†	[0.12]	−0.34*	[0.12]	1.00*	[0.06]	0.98*	[0.06]
Fraction of stock × *Laser*	0.73†	[0.33]			0.15	[0.21]		
Fraction of custom × *Laser* [H4]	**−0.86**‡	**[0.49]**			**−0.84***	**[0.25]**		
Fraction of design × *Laser*	−1.01	[0.79]			−0.49	[0.40]		
Fraction of distributor × *Laser*	0.4	[0.66]			0.74†	[0.34]		
Fraction of stock × *System*			−0.60†	[0.26]			0.26	[0.19]
Fraction of custom × *System*			**0.64**	**[0.55]**			**−0.03**	**[0.21]**
Fraction of design × *System*			−0.31	[0.66]			−0.38	[0.31]
Fraction of distributor × *System*			1.29‡	[0.77]			0.84*	[0.32]
Multimarket contact	−0.01	[0.01]	−0.01	[0.01]	0.05*	[0.00]	0.05*	[0.00]
Constant	1.12*	[0.10]	1.14*	[0.10]				
Observations	16,329		15,586		16,223		15,490	
Year FE	YES		YES		YES		YES	
Market FE	NO		NO		YES		YES	
Log likelihood	−36,941		−35,236		−24,102		−23,055	

Notes. Negative binomial regressions with the dependent variable *number 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 are for 1997–1998, as we do not observe entrants in 1997 and lagged entrants in 1998.

Coefficient estimates related to the hypotheses are shown in bold face; market-clustered standard errors in brackets; $^*p < 0.01$, $^\dagger p < 0.05$, $^\ddagger p < 0.1$.

Table 7 Estimates of Product Customization and Number of Exits at the Product Market Level

Column no.	9		10		11		12	
Estimation method	Negative binomial, pooled				Negative binomial, panel FE			
Estimation sample	All industries		Excluding lasers		All industries		Excluding lasers	
D.V. = *Exits*	Coef.	Se	Coef.	Se	Coef.	Se	Coef.	Se
Fraction of stock	−0.60*	[0.11]	−0.60*	[0.12]	1.61*	[0.05]	1.60*	[0.06]
Fraction of custom [H3]	**0.05**	[**0.11**]	**0.01**	[**0.11**]	**1.43***	[**0.06**]	**1.41***	[**0.06**]
Fraction of design	−0.02	[0.17]	−0.06	[0.18]	0.73*	[0.08]	0.73*	[0.08]
Fraction of distributor	−0.29†	[0.13]	−0.35*	[0.13]	0.87*	[0.06]	0.85*	[0.06]
Fraction of stock × *Laser*	0.41	[0.29]			0.35	[0.22]		
Fraction of custom × *Laser* [H4]	**−1.28***	[**0.41**]			**−0.97***	[**0.24**]		
Fraction of design × *Laser*	−0.38	[0.69]			0.06	[0.37]		
Fraction of distributor × *Laser*	0.87	[0.65]			0.87*	[0.32]		
Fraction of stock × *System*			−0.49‡	[0.26]			0.13	[0.18]
Fraction of custom × *System*			**0.38**	[**0.51**]			**0.25**	[**0.21**]
Fraction of design × *System*			0.14	[0.69]			−0.11	[0.30]
Fraction of distributor × *System*			1.17‡	[0.71]			0.92*	[0.31]
Multimarket contact	−0.01	[0.01]	−0.01	[0.01]	0.04*	[0.00]	0.04*	[0.00]
Constant	1.81*	[0.11]	1.85*	[0.11]				
Observations	16,073		15,347		15,998		15,279	
Year FE	YES		YES		YES		YES	
Market FE	NO		NO		YES		YES	
Log likelihood	−37,429		−35,816		−24,724		−23,679	

Notes. Negative binomial regressions with the dependent variable *number of exits*. All explanatory variables are lagged by one period. The sample for estimations is obtained by excluding observations for the years 1997 and 2009 because the lagged values are missing for 1997 and exits are censored for 1999.

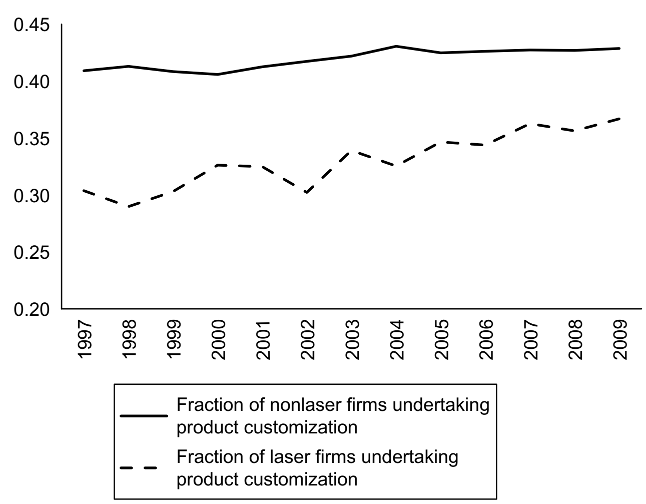
Coefficient estimates related to the hypotheses are shown in bold face; market-clustered standard errors in brackets; $^{*}p < 0.01$, $^{\dagger}p < 0.05$, $^{\ddagger}p < 0.1$.

5.4. Limitations of the Study

One may argue that our results are confounded by the potential coordination among customizing firms to keep entrants out (Barnett 1993). All our results are, in fact, robust to the inclusion of a measure for multimarket contact, showing that the deterrent effect is distinct from any coordination among firms in these industries. The intensity of local competition can drive the longevity of customizing firms in our sample (Hsu et al. 2014). Yet our results are robust to the inclusion of California dummy as a control. Our results would probably not be replicated if we replace the upstream laser industry, known for its many submarkets, with another industry. Indeed, consistent with this logic, the downstream laser system industry does not yield results similar to those observed for the upstream laser device industry. It is possible that firm survival may lead or at least precede customization. In particular, as an industry matures and growth slows down, the surviving firms have an incentive to engage in product customization to find growth opportunities and expand into previously neglected segments (Abernathy and Clark 1985). However, we do not expect such reverse causality to explain our findings because we estimate the hazard of exit *conditional* on survival, use one-period lagged values of explanatory variables, and control for product age and industry time effects.

Notwithstanding the above robustness checks, some omitted variable can drive both survival and the survivors' subsequent adoption of customization services. However, in our data set, the fraction of surviving firms that undertake product customization services does not change dramatically over time and is lower for the laser industry than for other industries (see Figure 3). It is difficult to explain, then, why the fraction of the laser firms in our

Figure 3 Fraction of Firms Undertaking Product Customization Over Time



Note. Figure 3 shows the fraction of customizing firms in both upstream lasers and other industries over time.

data set that offer product customization services remains one-third, while the annual exit rate is 15%. Our analyses rule out firm, market, and time-specific factors as potential omitted variables. In addition, our inferences are not merely about the correlation between product customization and firm survival but about between-industry differences in that relationship. For these reasons, it is less likely that our results are driven by reverse causality or endogeneity. As shown in Figure 3, only 30%–40% of the firms in our data set undertake product customization consistent with the findings of previous studies (Xia and Rajagopalan 2009, Syam and Kumar 2006, Terwiesch and Loch 2004)—thus reflecting the reliability of our data. If firms had an incentive to misreport their customization activity, one would expect systematically more firms to do so. It is also difficult to explain why such firms live longer in our data set if they simply misreported.

Nonetheless, an important limitation of our study derives from the coarse nature of the measure of submarket potential. A continuous measure of submarket potential reflecting the general-purpose nature of the underlying technology in an industry and varying across industries would have allowed us to better exploit between-industry variation in product customization and explain firm survival. While we argue that the upstream laser industry dummy proxies for its higher submarket potential, there might be other factors about the laser industry that explain our empirical findings.

An additional limitation of our study is that our analyses omit factors that affect entry barriers, such as the Herfindahl index of market concentration, R&D, and advertising intensity. For example, a market that has a high fraction of customizers could be a very competitive one, which is consistent with our result that the fraction of customizers is positively associated with the number of both entries and exits. However, if the upstream laser industry has relatively higher barriers to entry, then it features fewer entries and exits, which would be consistent with our negative interaction coefficients in Tables 6 and 7. Our ability to control for entry barriers is limited by the lack of financial information about the 8,966 firms in our data set, most of which are small, privately owned firms. Nonetheless, our results in Tables 6 and 7 supporting Hypothesis H4 are robust to the inclusion of a one-period-lagged number of firms in the product market as a proxy for its competitiveness (the results are available upon request).

Finally, firm fixed effects are generally not adequate to control for firm quality, as the time-varying component may explain our findings. This remains a limitation of our study. However, given the limited within-firm variation in product customization over time and the 13-year panel employed in our study, we do not expect drastic changes in firm quality to explain our results.

6. Discussion

Firm longevity in an industry is generally linked to a firm's ability to mass produce standardized goods by exploiting economies of scale and scope (Chandler 1990, Hounshell 1984). The mass production view offers a good explanation of the historical rise of several businesses and industries in the United States and several regularities concerning industry evolution (Gort and Klepper 1982, Klepper 1997). Yet many other industries feature striking levels of product customization that belie their standardized industry classification codes (Pine 1993, Gilmore and Pine 2000). Many product firms increasingly offer product customization services to respond to consumer needs and improve their financial performance (Cusumano et al. 2015, Suarez et al. 2013).

The study of product-related customization services and industries dominated by multiple submarkets is underrepresented in the literature (Gambardella and McGahan 2010, Anderson and Tushman 1990). Theories of industry evolution based on the mass-production view are inadequate to explain the between-industry heterogeneity in firm survival and patterns of entry and exit in industries. Our paper builds on recent studies that advance the theory of industry evolution by incorporating the role of services (Cusumano et al. 2015, Suarez et al. 2013) and submarket dynamics (Klepper and Thompson 2006, Sutton 1998).

We investigate the moderating role of submarket dynamics on the product customization–firm survival relationship and provide evidence for two separate mechanisms: submarket pioneering and entry deterrence. These *cumulative* and *preclusive* components of the longevity of customizing firms reflect their ability to appropriate returns from both present and future market opportunities in industries dominated by submarkets (Ahuja et al. 2013). 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, sometimes, to the proliferation of independent submarkets (Adner and Levinthal 2001, Christensen 1997).

The literature on user innovation discourages product customization by firms. In examining two industries in which product customization dominates, von Hippel (1998) argues that users generally undertake product customization since they face lower information and transaction costs of customizing products relative to the suppliers. Therefore, von Hippel (1998, p. 631) argues that suppliers may profitably cede to users' "*application-specific portion* of the problem-solving work of custom product and service design." Yet our results document considerable between-firm heterogeneity in customization activity and their consequences for firm survival, suggesting that the strategic benefits of taking up product customization can sometimes outweigh the cost associated with coordinating with users.

Several issues remain to be addressed in future research. Whereas this study provides strong evidence that product customization is associated with longer firm survival in submarket-rich industries, future research can examine the heterogeneity in the organization of search for submarkets and its differential consequences. Although we document the positive impact of product customization on incumbents in the laser industry, future studies could examine other industries and stages of the industry life cycle, where product customization can lead to other effects. Historically, the automobile industry in the United States 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 the 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, which it had established mainly by mass-producing a standardized product. These anecdotes indicate the uneven impact of product customization on firm survival over the industry life cycle and highlight the need for more research in this domain.

Another promising research avenue is the impact of product customization on the geography of industries. Klepper and Sleeper (2005) show that, although the laser industry did not cluster regionally in the United States, intra-industry spinoffs did cluster together and were also more likely to survive longer. Klepper and Thompson (2010) argue that some of the intra-industry spinoffs across several industries resulted from the parent firm's reluctance to pursue custom product varieties. Thus, we wonder: does product customization lead to the clustering of successful firms in an industry and deter other regions from gaining a foothold? Future research can investigate this question.

Endnotes

[1]The U.S. automobile industry, for example, is a celebrated case in which firm survival is explained variously by technological change, firm capabilities, entry strategies, production choices, and product life cycle–related factors (Argyres et al. 2015; Argyres and Bigelow 2007; Klepper 2007a, 2002a; Carroll et al. 1996). Prior studies examine firm survival in a range of other industries, such as semiconductors (Klepper 2007b, Barnett and Freeman 2001), hard drives (Franco et al. 2009, Christensen et al. 1998), laser printers (de Figueiredo and Silverman 2007, de Figueiredo and Kyle 2006), medical devices (Chatterji 2009, Mitchell 1989), personal computers and software (Bayus and Agarwal 2007), and ship building (Audia and Greve 2006, Thompson 2005), among others.

[2]Prior studies also identify significant between-industry heterogeneity in the nature of demand (Adner and Levinthal 2001), the timing of sales take-off (Agarwal and Bayus 2002), the generality of underlying technology (Bresnahan 2010, Gambardella and McGahan 2010), the character and extent of innovation and appropriability (Cohen et al. 2000, Ahuja et al. 2013), and the extent of product customization (Xia and Rajagopalan 2009, Bernhardt et al. 2007). Between-industry differences determine the effectiveness of employing specific firm strategies (Suarez and Lanzolla 2007), reflecting the relative importance of macro, industry-specific factors, such as submarket potential, in determining firm survival (Franco et al. 2009).

[3]According to Jaffe et al. (1993), for patents, "generality" is one minus the Herfindahl index across patent classes of the citations received. The measure attempts to capture the extent to which the technological "children" of an originating patent are diverse in terms of their own technological location.

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