IN THE BUD?
ANALYSIS OF DISK ARRAY PRODUCERS AS A (POSSIBLY) EMERGENT ORGANIZATIONAL FORMS

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Abstract

When and where will a new organizational form emerge? Recent theory says that as the number of organizations using a particular external identity code first increases beyond a critical minimal level, the code becomes an organizational form. But how is an external identity code established? We assume that the identity code derives from the aggregated identities of individual organizations. Our core argument holds that when the identities of individual organizations are perceptually focused, they will more readily cohere into a distinct collective identity. We develop ideas about how two observable aspects of organizations might generate perceptually focused identities in a common market: (1) *de novo* entry and (2) agglomeration in a geographic place with a related identity. Using comprehensive data from the market for disk drive arrays, we analyze these ideas and an alternative by estimating effects of different specifications of organizational and product densities on rates of entry and exit for array producers. The findings show that the density of *de novo* firms affects all *(de alio* as well as *de novo*) disk array producers in form-establishing ways: *de novo* density significantly increases all firm entry and significantly reduces all firm exit. Analyzing densities of certain geographic areas, we also find evidence of faster form development in a place with a related identity and a geographic agglomeration of disk array producers. Finally, we find that joint operation of the two processes, geographic agglomeration of *de novo* producers in a place with a related identity, serves to enhance form emergence even faster. Overall, the analysis supports the notion that firms with perceptually focused identities aid in establishing an organizational form. It does not show empirical support for a common sense alternative interpretation based on product proliferation.

INTRODUCTION

In 1986, a little-known Dutch company named Twincom introduced a software product designed to manage "disk drive arrays," which are data storage subsystems linking several (or many) hard disk drives. In the following year, disk array products were introduced by an additional seven companies: 1776, Atlantic Microsystems, Core International, Ford/Higgins, Maximum Strategy, Thinking Machines, and Micropolis, a disk drive manufacturer. Little over a decade later, disk arrays had a well-established world market and were widely used: over $12.6 billion of disk array products were sold in 1998 by 130 different producers.

In a very different domain, namely beer, another new market was developing around the same time. In 1977 the New Albion Brewing Company opened in Sonoma, California. It joined the existing (but recently transformed) Anchor Brewing Company of San Francisco in offering heavier, full-flavored malt beverages (e.g., ales, porters, stouts) not found in the American market for beer. In subsequent years, others followed; by 2000 the economic contribution of mainly small "craft" breweries was estimated at $11 billion. It includes scores of producers such as Anchor commonly known as "microbreweries" as well as hundreds of other producers known as "brewpubs." The brewpub also makes full-flavored malt beverages using craft techniques but serves them at the site of production, usually in conjunction with food. Founded in 1987 in Hopland, California, the Hopland Brewery is widely recognized as the first brewpub in the U.S. since Prohibition.

Chances are that the microbrewery and brewpub terms will be familiar while the disk array producer term (or anything similar that would describe specifically the firms in this market) will not be. Chances are also that it would not take much thought to name a microbrewery or brewpub but it would take some research to name a disk array producer other than one of those listed above. The comparison thus raises two questions. First, does it matter that in the one market we have readily accessible descriptive "labels" to classify and distinguish participating firms while in the other we do not? Second, presuming it does matter, how can we account for the difference in public cognitive status of the various organizations?

Our answer to the first question is affirmative. In our view, the ready accessibility of classificatory terms for types of organization derives directly from whether or not a particular type of organization constitutes an organizational form. This view relies on a definition of form as a recognizable pattern of activity that takes on rule-like standing, which Pólos et al. (2002) call a code. As we describe below, the term code here denotes and connotes both cognitive recognition and imperative standing. By this definition, a form is an external identity code, meaning that it is the perceptions and opinions of "outsiders" that matter. The external identity code possesses rule-like status, so that its observable violation is negatively sanctioned--it causes outsiders to drop discontinuously their valuation of the entity to which it is applied.[1]

As we explain below, our concept of organizational form implies legitimation or social-taken-for-grantedness (sometimes called constitutive legitimation). Much contemporary organizational theory treats legitimation as both privileging and constraining. An organization possessing a (legitimated) organization form appears unproblematic and can be interacted with and regulated unambiguously; accordingly, it typically benefits from greater access to resources, more protection from authorities, and higher visibility—all provided the organization does not violate any of the form-specific rules constraining its appearance and behavior (Meyer and Rowan 1977; Zuckerman 1999). The approach we use here regards establishment of legitimation as a process where positive returns potentially increase from the first appearance of a potential organizational form up to a subsequent ceiling, signalling the organizational form's establishment. These positive returns of the form-establishment process involve ease of organizing, resulting in higher rates of organizational founding and enhanced life chances for the organizations using the potential form.

Accepting our answer to this first question means that the second question actually asks: When and where will a new organizational form emerge? In an exploratory case study of the disk array market, McKendrick and Carroll (2001) examine arguments drawn from organizational theory and juxtaposed them with basic facts of the situation. They find that the disk array organizational form has not developed, despite the presence of formal institutions representing collective action and ecological processes often associated with form emergence. They speculate that the reason the form had not crystallized lies in organizational diversity: the heterogeneous set of origin industries spawning and still supporting disk array producers (i.e., continuing to provide the bulk of many firms' revenue) makes it difficult for the disk array producer organizational form to gain perceptual recognition and take hold. The difficulty arises because form establishment is essentially about identity formation: if many firms in the market derive their primary identities from other activities and there are few firms deriving their primary identity from disk arrays, then the disk array producer identity will likely not be readily perceived by outsiders, thus impeding its coherence into a code or form.[2]

As we argue in depth below, the case materials of McKendrick and Carroll (2001) suggest a reformulated specification of the density-dependent process commonly thought to generate a legitimated organizational form. More precisely, we claim that an organizational form emanates from the density of producers with perceptually focused identities in a market rather than the total density number typically used by ecologists. Among other possibilities, we argue that the perceptions of outsiders will be more focused when the identities arise from (1) *de novo* entrants and (2) entrants that are concentrated in geographic locations that possess related identities. As we show below, either formulation can be readily incorporated into extant models and theories of density-dependent legitimation and tested more rigorously.

This report describes statistical analyses designed to test systematically these arguments. We use firm-level event-history data collected for every producer to enter the market for disk arrays worldwide, from Twincom's initial introduction to the end of 1998. We estimate models of organizational entry and exit specified to examine the effects of a variety of firm-level and industry-level factors. While these models serve here mainly to test our arguments about perceptually focused identities, the analysis might inform other topics of broad interest--including especially spatial agglomeration.

PRIOR THEORY AND RESEARCH ON FORMS

Romanelli's (1991: 81) review of the literature on the emergence and establishment of new organizational forms claims that "no theoretical consensus exists regarding an approach to the problem" and that "the conceptual approaches are diverging." More tellingly, Romanelli also finds no generally accepted common definition of the form concept. She determines that from the many theoretical arguments about form emergence that had been proposed, "no overarching themes for integrating these perspectives" could be identified (Romanelli 1991: 100).[3] Romanelli concludes on a positive note: she advises organizational theorists to embrace the conceptual diversity about forms, to emphasize differences among various conceptualizations and to illustrate the quality of various definitions through theoretically directed empirical research.

In the period since Romanelli's (1991) review, usage of the organizational form concept has probably become even more elastic.[4] Accordingly, we believe that organization theory could still benefit from greater attention to the form concept. As Romanelli (1991: 81-2) notes, at the broadest level, "the concept of organizational form refers to those characteristics of an organization that identify it as a distinct entity and, at the same time, classify it as a member of a group of similar organizations." Indeed, many proposed definitions are so highly abstract they lack empirical bite. For example, in his pioneering book on organizational classification, McKelvey (1982: 107) first defines form as "a concept to broadly capture the character of an organization's structure, function and process." He then later redefines it as "that which is measured by taxonomic characters" and suggests that "the best strategy for selecting taxonomic characters is to measure everything possible" with an emphasis on "characters associated with dominant competence and evolutionary/ecological importance" (McKelvey, 1982: 214).

The most common type of definition uses specific features of organizations to identify and define organizational forms (Carroll and Hannan, 2000; Pólos, Hannan, and Carroll, 2002). This approach emanates from Weber's (1968) analysis of the rational-legal bureaucracy, which he defines in terms of features such as authority, procedures, and the employment relation of the official. The feature-based conception of form has developed to recognize that some features--so-called "core" features--are more important than others in distinguishing forms (Scott, 1998). Organizations with the same core features belong to the same form, by this view.

A second popular definition of organizational form is based on the presumption that distinctions among forms reflect social processes and boundary creation (DiMaggio 1996; Hannan and Freeman, 1989). In this view, the clarity and strength of social boundaries define forms--sharper boundaries generate clearer forms. The key to understanding forms, then, involves looking at the processes that create and maintain boundaries, including social networks, technological change, closed flows of personnel among a set of organizations, changes in patterns of resource flows, and the like.

In the view of Pólos and colleagues (1998, 2002), both types of definitions of form suffer limitations, the most serious of which is the lack of connection between forms and identities (see also Ruef, 1999; Zuckerman and Kim, 2003). By their view, the form classification rules of organizations should not be divorced from the social world because it involves social and cultural typifications--widely agreed-upon classifications of entities into types (Meyer and Rowan, 1977; Scott, 1995). Empirical research on such processes suggests that they build upon organizational identities (Zuckerman, 1999, 2000; Ruef, 2000).

THEORY: FORM AS IDENTITY

The research reported here follows Romanelli's (1991) suggestion to demonstrate the value of specific definitions of form through empirical research rather than try to incorporate many meanings into a single analysis. Accordingly, in asking how and when organizational forms emerge, we follow Pólos et al. (2002) in defining an organizational form as a recognizable social code that possesses rule-like standing. As mentioned above, their term code denotes and connotes both cognitive recognition and imperative standing. So, a code can be understood as (1) a set of interpretative signals, as in the "genetic code" and (2) as a set of rules of conduct, as in the "penal code."

In the Pólos et al. (2002) formulation, the key identity code for an organizational form is external. There are potentially an infinite number of forms but only activities that acquire external recognition and are constrained by the sanctions of outsiders gain form status; forms do not exist independent of external agents. Identity codes for organizational forms typically consist of abstract features as well as composition rules about appropriate combinations of particular features.

A form identity applies to multiple organizations and persists longer than an ordinary identity. This is because once established, a form identity gets embedded in other societal institutions such as languages, directories and public labels. For example, the yellow pages of the phone book gives a very basic set of organizational forms for many (but not all) of the entries. With more technical markets, such as that for disk arrays, it may be useful to look at how technical and buyer-oriented publications place firms into groupings, how companies refer to themselves and their products in advertisements and other public announcements, and how gatekeepers to critical resources such as capital and labor categorize firms**.** Many of the classifications built into these sources reflect the implicit rules about forms used by external gatekeepers to organize, evaluate and sanction individual organizations.

Form emergence

Although a particular set of organizational features might develop an external identity, this does not mean the identity is an organizational form, unless it is also enforced and taken-for-granted by outsiders, i.e., the identity must be codified, socially embedded and sanctioned. An implication of this construction is that it "allows us to define populations that never achieve form status and to extend meaningfully the definitions of populations back to the period of early legitimation" (Pólos et al., 2002: 107). Thus, populations are not defined by forms, as received ecological theory does, but instead by identities, the most specific external identities applicable (minimal identities).

When will a specific (nascent) external identity become an organizational form? Pólos et al. (2002) link the form-generation process to prevalence or organizational density. They specify a form-specific application number, $\nu(\phi)$, that marks the number of organizations to which a social identity must apply for the identity to gain organizational form status. That is, identities become forms at varying points in population histories, depending on $\nu(\phi)$ and their density levels. Moreover, the form-specific number $\nu(\phi)$ represents the density N_ϕ at which the legitimation enhancing returns of new organizations joining the population reach a ceiling. This means that "the period in a population's history between its inception and the time at which density surpasses $\nu(\phi)$ is the crucial period of legitimation in the sense of taken-for-grantedness" (Pólos et al., 2002: 107).

In the case of a potential new form identity, application of this idea might be straightforward: from inception count the number of organizations N holding the minimal identity at various periods t and then look during each period for other phenomena typically associated with a legitmated organizational form. The point at which these phenomena are first seen should coincide roughly with $N(t)=N_\phi=\nu(\phi)$. Following this strategy, McKendrick and Carroll (2001) find that the number of disk array producers entering the market rises steadily over the early years, eventually slowing down and stabilizing and, finally, declining slightly.[5] From received ecological theory, it would thus make sense to infer that the disk array identity became a form around the time and density level of the population when it reached stabilization. However, other compelling information made it clear that the identity had yet to develop into a form, thus leading McKendrick and Carroll (2001) to conclude that the theory was deficient.[6]

For example, although the industry information service provider Disk/Trend classifies disk arrays as a single industry, we know from extensive interviews with executives and others that this classification category is only one of several ways participants and outsiders perceive the market, even in the period after organizational density has stabilized. Other relevant outsiders, such as security firms' market analysts, seldom focus on a disk array (or similarly termed) industry, preferring instead to stay at the more encompassing level of "data storage" (see Hambrecht & Quist, 1998; Tucker Anthony, 1998). Moreover, these analysts' reports usually do not contain sub-groupings based on the disk array form or organizational type; instead individual companies and their particular technologies or product lines (e.g., video or audio streaming, transaction processing, web caching) are described. Looking at insiders to the market, a similar lack of consensus about appropriate form is evident. So, for instance, companies refer to themselves variously as involved in "storage," "storage subsystems," "RAID (Redundant Array of Independent Disks)," "disk arrays," "network attached storage" and others. As the director of product marketing at Maximum Strategy says, "Companies are starting to go away from saying [disk arrays], and are instead talking about what they offer. We provide high bandwidth" (Electronic Engineering Times, 3/25/96). One prominent company even went so far as to publish a book attempting to clarify the many confusing terms in the industry (Network Appliance 2002).

Figure 1 provides some data about this identity ambiguity. The data come from searches on the various identity labels that we have conducted using Lexis-Nexis. For each year from 1985 to 2000, we searched the full texts of all business and finance articles in the business category of Lexis/Nexis to count the number of times a particular identity label was used. Figure 1 shows two plots: one gives the count for articles that used the word strings "disk array" and "company" at the same time, while the other gives the counts for uses of the exact word string "data storage company." Obviously, usages of both terms rise in the period, suggesting possible identity formation. However, while the disk array usage was more common in the early years, it becomes overtaken by the more restrictive search on "data storage company" later. This suggests to us that the disk array form is likely not yet fully established and that the identities remain in flux.

(Figure 1 about here)

Perceptually focused identities

McKendrick and Carroll's (2001) case study leads us to pursue a different argument and specification of the form emergence process. Specifically, we believe it is imperative to take into account the perceptions of external agents (such as financial analysts, bankers, suppliers, distributors, potential employees and customers). After all, it is through these agents' perceptions and sanctions that form identities emerge and persist.

The basic problem, then, is when and how do these external actors perceive that a set of organizations with which they potentially interact possesses a new identity that should be subject to some sanctioning? We propose that such perception occurs more readily when the identities of the individual organizations in a population somehow become focused on (at least some of) their common components. This means that the perceptions of external actors are directed to some salient common features of a set of organizations and that there is (perhaps implicit) recognition of this commonality as a distinctive social entity (the identity or nascent form). Of course, the specific ways that perceptual focus occurs likely vary by context—both organizations and types of external actors will differ in important ways. So, after developing the general point, we will turn to two different ways that we think identities might become perceptually focused in the disk array market. The two ways concern (1) the extent to which an organization's activity base resides inside the focal market and (2) the extent of agglomeration within a geographic place with a preexisting identity related to the potential form.

In our view, perceptually focused identities are important for a variety of mutually reinforcing reasons. First, focused identities mean that both insiders and outsiders will be more likely to recognize and identify something distinctive. So, focus increases salience. Second, the greater homogeneity of organizations with focused identities implies that form boundaries and exclusion rules are simpler. Simpler boundary rules make policing or sanctioning possible (Zuckerman, 1999). Third, salience and homogeneity provide the seedbed for generating solidarity and organizing for self-promotion and defense (Buechler, 2000).

If these speculations are valid, then they lead to a reformulated specification of the density-dependent form-generation process advanced by Pólos et al. (2002). We retain the core idea that identity of a form derives the aggregated identities of individual organizations; we also retain the form-specific application number $\nu(\phi)$ for achieving form status. However, rather than base this number on density per se, we propose to base it on the number of organizations with perceptually focuses identities, N_{ϕ}^{P} . Now an organizational form emanates from initial rises (when density is low) in the density of producers with perceptually focused identities in a particular market rather than from initial rises in total density. In other words, form ϕ emerges at time t when $N^{P}(t) = N_{\phi}^{P} = \nu(\phi)$. So, we posit

> Theoretical Proposition: Establishment of an organizational form is positively related to initial rises (when density is low) in the density of organizations with perceptually focused identities.

An Alternative Argument

Of course, in a newly developing market, the products of participating organizations may also be highly visible. When some organizations produce multiple products, this possibility raises the question of whether collective identities are built around products or organizations. The case for organizations comes from their multidimensional nature: identity springs from their joint presence in labor, product and financial markets, among others (Baron 2002). Products develop identities in more restricted arenas, but these may be very large from the perspective of individuals and reflect heavily on the underlying producer organization. Indeed, individual perceptions of particular organizations likely spring from experiences with products, not only in use but through advertisements, demonstrations at trade shows, press releases, and the like. If so, then organizational form identities might emerge from the number (density) of products promulgated by producer organizations. This possibility suggests:

> Alternative Theoretical Proposition: Establishment of an organizational form is positively related to initial rises (when density is low) in the density of products associated with a particular activity.

EMPIRICAL HYPOTHESES

For empirical research, an advantage of the Theoretical Proposition is it can be readily incorporated into extant models of density-dependent legitimation. As explained above,

N_{ϕ}^{P} represents the density level where an identity acquires the character of a form, meaning that it is fully legitmated or taken-for-granted. Before this point, as $N^{P}(t)$ grows from *0* to N_{ϕ}^{P}, the taken-for-grantedness of the identity increases by at least two mechanisms (Hannan and Carroll 1992: 41): (1) "collective action by members of the population to define, explain and codify its [potential] organizational form and to defend itself from claims and attacks of rival populations" and (2) "collective learning by which effective routines and social structures become collectively fine-tuned, codified and promulgated." Ecologists claim that the strength of both mechanisms tracks organizational density; and substantial empirical research on a variety of populations shows that as density rises from early low levels, organizational founding rates increase and mortality rates fall, exactly as increasing legitimation would lead one to expect (Carroll and Hannan 2000). Accordingly, a similar empirical test of the Theoretical Proposition would consist of relating $N^{P}(t)$ to the vital rates of an emergent organizational population.

But fully specifying a model for empirical testing requires further conceptual elaboration, namely, linking the perceptually focused identity concept with measurable characteristics of organizations. That is, what is a good way to calculate $N^{P}(t)$? Of course, one can imagine many sophisticated instruments or methods designed to measure focus in organizational identity. But many of these would be impossible to apply to non-existing, previously failed organizations. To overcome this obstacle, we prefer (at least in this initial exploration) to use readily identifiable observable organizational characteristics that can be ascertained systematically from the historical record. This approach also facilitates comparative analysis (Carroll and Hannan 2000).

Which observable characteristics? As explained, McKendrick and Carroll (2001) conjecture that the disk array producer organizational form did not fully take hold in the observed early phase of the market because disk array producers come from a heterogeneous set of origin industries and often retain operations in those industries, perhaps still deriving the bulk of their revenue therein. By this view, the problem resides in the externally perceived basis of firms' identities: so long as firms in the disk array market derive their primary identities from other activities and so long as there are few firms deriving their primary identity from disk arrays, then the disk array producer identity seems unlikely to be perceived by outsiders. That is, the high levels of organizational diversity and diversification make it unlikely that the common disk array features will cohere into a code or form of its own; the external perceptions of identities are not focused in this context. We imagine that there are many other cases of established markets without specific organizational forms because the supplier firms are primarily engaged in other identity-defining activities (these could be vertically or horizontally related to the focal market) that blur external perception.

De Novo Entry Status

McKendrick and Carroll (2001) use these general arguments to claim that in the disk array market, *de novo* firms possess greater focus than *de alio* firms that come into the market from a wide variety of other activities in which they often remain active. This means that initially--when density is low--a density count of *de novo* firms should show legitimation-enhancing effects on the whole set of producers. In this sense, focus is about perception: focus helps outsiders see and legitimate the activity, not improve the life chances of *de novo* firms themselves. That is, we set $N^{P}(t)$ to record *de novo* producers and stipulate

> <u>Hypothesis 1a</u>: Organizational founding rates of all organizations engaged in a particular production activity rise with initial increases (when density is low) in the density of *de novo* producers engaged in the same activity.
>
> <u>Hypothesis 1b</u>: Organizational mortality rates of all organizations engaged in a particular production activity decline with initial increases (when density is low) in the density of *de novo* producers engaged in the same activity.

This formulation is also more consistent with the market's overall empirical trends. Specifically, McKendrick and Carroll (2002) show that, unlike total density, the annual density of *de novo* disk array producers does not rise to a stable point and then subside. Rather, *de novo* density appears to be still in a growth phase. More importantly, because it does not level off and is still rising upward, the trajectory of *de novo* density does not give the general impression that the identity should be legitimated. It suggests instead that the identity is undergoing institutionalization and may not yet be fully legitimated.

Although this formulation appears theoretically sound and empirically consistent with the facts of the disk array case, it should be noted that it disagrees with one drawn from another popular perspective on legitimation. Precisely, the so-called socio-political view of legitimation holds that endorsement by powerful actors yields advantages to organizational forms and aids in the process of legitimation (Scott, 1995). It follows logically then that if and when larger established (powerful) organizations enter a market, then legitimation should be enhanced. IBM's entry into the PC market is a well-known case that seems consistent with this argument. In terms of organizational density by entry mode, the prediction most consistent with this view would be that *de alio* density contributes the greatest to legitimation. This is because *de alio* entrants will usually be larger and more powerful than *de novo* entrants.[7]

The intuition behind Hypotheses 1a and 1b comes from perceptual considerations based on viewing organizations in a focal market as whole social entities. It assumes that external actors see or know about aspects of the participating organizations that transcend the focal market, if they do. From this perception, the common component of focal market participation (i.e., the potential new form) is more likely to dominate when more organizations operate mainly in the focal market (*de novo* entrants). By contrast, diversified firms may interact with external agents in ways that do not heighten perceptions of the focal market. For example, the financial reports of publicly traded firms may not highlight some of the smaller new markets in which the firms are engaged.

Agglomeration in a Geographical Place with a Related Identity

Another different intuition about perceptually focused identities arises from considerations based on outsiders' views of those organizations most frequently encountered socially. The idea here is that if one's high-frequency interaction partners include many instances of organizations with the potential new organizational form, then one is more likely to recognize (at least implicitly) and sanction the form. A second-order network effect may also occur: one's perception of a possible form is heightened when many of one's interaction partners interact with organizations possessing the common properties.

Of course, the interaction patterns of external agents with respect to organizations and each other are extremely difficult to discern and measure, especially those occurring in the distant past. This potential intractability of direct measurement leads us to pursue an alternative research strategy involving comparisons of the effects of organizations grouped by various geographic locations. We focus in particular on those locations with high numbers of firms in the focal market and with place identities recognized by the market participants and external agents. We do so because, compared with other locations, these places likely have identities related to the new activity, thereby providing more focus to outsiders' perceptions.

Geographers and other scholars of regions and regionalism commonly view localities as socially-defined perceptual units that only exist in relation to particular criteria (Allen, Massey, and Cochrane, 1998; MacLeod, 2001). Although places have a real physical environment and a spatial dimension, they are not defined by a precise geographic boundary. Rather, they become known with regard to different spheres of social action and so may have multiple identities: political, cultural, social, and economic. In this regard, they are a medium for social interaction, and their identities are socially constructed. As Paasi (1996: 8) puts it, "individual actors and collectivities are socialized as members of specific territorially bounded spatial entities and ... more or less actively internalize territorial identities and shared traditions." The very naming of places helps to construct their identities, connecting their images with the perceptions of insiders and outsiders. Academics, journalists, regional protagonists, business executives and politicians employ language to popularize, establish and sustain places in the consciousness of society (Carr, 1986; Paasi, 1996; MacLeod, 2001). A place explicitly comes into being and acquires an identity through these discourses (Pred, 1989).

The place identities of interest here relate to the industrial world. Social scientists have long noted that firms in the same market often agglomerate (Marshall, 1920; Weber, 1929; Hoover, 1948). By agglomerating, firms increase their interactions with each other and make collective action more likely. Agglomeration also often produces a common perception among participants and outsiders that something with an identity resides therein. A local culture emerges that defines or unifies organizational actors through a mutual awareness of their common industrial purpose (Storper, 1995). This coherence consists of a similar spirit of enterprise, organizational practices, action rules, customs, understandings and values (Saxenian, 1994). Indeed, in describing particular agglomerations, analysts typically use language strongly suggesting that organizations derive public cognitive recognition from clustering with similar others; this is especially true for those who have written about Italian "industrial districts" (Brusco, 1982; Piore and Sabel, 1984; Becattini, 1990).

Of course, many geographical places possess socio-economic identities. The sheer number of organizations and employees in a related activity can make them a coherent identifiable organizational community. But our sense is that prevalence in itself does not contribute to the emergence of an organizational form. Rather, a form often exists before a place becomes identified with it. For example, although Dalton, Georgia, is typically seen as the world's carpet manufacturing center, we suspect carpet-making already existed as a form before Dalton acquired that identity.

We think that a strong place identity can override firm differences to contribute to form emergence in two general ways. One is if the geographic area is a known place with a preexisting social identity of its own. For instance, Silicon Valley and Route 128, which feature prominently in the market for disk arrays, are known for their excellence across several technological markets. Organizations in these milieux have a collective identity as "technology firms," thereby signaling to external actors that they are members of a community known for the creation of new firms, technologies, and markets. A second way is a subset of the first, where the place has a preexisting identity related to or closely associated with activities in the new market. For instance, such a place may have had a reputation as a center of data storage, and so this identity would confer greater visibility on the disk array firms located there. We submit that forms are more likely to emerge out of locales with preexisting related place identities because external agents already associate these places with similar kinds of activities, thereby giving the new activity greater perceptual focus.

So, when firms in a particular new market agglomerate in places with related social identities, we conjecture they will be more likely to generate a coherent identity of their own and thus an organizational form. That is, this argument sets $N^P(t)$ to track the density of geographically agglomerated producers in a place with a related identity and states

> Hypothesis 2a: Organizational founding rates of all organizations engaged in a particular production activity rise with initial increases (when density is low) in the density of geographically agglomerated producers in a place with an identity related to the same activity.
>
> Hypothesis 2b: Organizational mortality rates of all organizations engaged in a particular production activity decline with initial increases (when density is low) in the density of geographically agglomerated producers in a place with an identity related to the same activity.

It is useful to examine how this formulation relates to other recent work in organizational ecology that has also advanced theoretical ideas about geographic boundaries and legitimation. Both Hannan et al. (1995) and Bigelow et al. (1997) argue that social legitimation of a form operates on a broader geographic scale than competition because political and physical barriers are more likely to interrupt the exchange of goods and people than they do ideas or cultural images. This argument leads to a multilevel specification of density dependence, with density for legitimation counted across geographic boundaries and for competition counted only within boundaries (Bigelow et al., 1997; Hannan, 1997). Although Hypotheses 2a and 2b may at first blush appear at odds with these claims, there are at least two reasons they need not be. First, Hannan et al.'s (1995) theory can be seen as concerning the legitimation within a newly emergent population of a form previously established in another context (a type of diffusion), while the current hypotheses address the initial emergence of an organizational form in any population. Second, Hannan et al.'s (1995) argument involves claims about the exchange of information across (and thus the interdependence of) various geographic units, which are essentially about where to draw the population boundaries rather than how to count density once the boundaries are determined. In any event, neither potential complication pertains to this study given that it is about a potentially new form in a single worldwide population.

Combining the Arguments

Now, consider the possible joint operation of the two theorized perceptually-driven processes. Our view is that when *de novo* producers possess focused identities and congregate in a particular geographic area with a related place identity, the two processes should combine to speed up legitimation even faster than their individual effects. This is because the two processes operate in different ways. *De novo* density represents a process of simple accretion in collective identity: each member possesses (virtually) the same identity and as more members enter the market, the identity gains force by sheer numbers. By contrast, the agglomeration process involves the muting of many other aspects of firm identity and causes attention to cohere around the common dimension. Although different, the two processes do not work in opposition. So, interacting regularly with many organizations possessing the same apparent features should accelerate identity formation and legitimation of a potential organizational form initially when density is low.

> Hypothesis 3a: Organizational founding rates of all organizations engaged in a particular production activity rise with initial increases (when density is low) in the density of geographically agglomerated *de novo* producers in a place with an identity related to the same activity.

> Hypothesis 3b: Organizational mortality rates of all organizations engaged in a particular production activity decline with initial increases (when density is low) in the density of geographically agglomerated *de novo* producers in a place with an identity related to the same activity.

The Alternative Product Argument

Finally, we turn to the alternative theoretical proposition based on product density rather than organizational density. It is rather straightforward to develop a basic pair of hypotheses linking product density to form establishment:

> Alternative Hypothesis 1a: Organizational founding rates of all organizations engaged in a particular production activity rise with initial increases (when density is low) in the density of products associated with the same activity.

> Alternative Hypothesis 1b: Organizational mortality rates of all organizations engaged in a particular production activity decline with initial increases (when density is low) in the density of products associated with the same activity.

In addition, we test a refinement of these arguments using more narrowly defined counts of product density that might be related to product visibility and identity: the density of products for the non-captive array market of original equipment manufacturers (OEMs) or plug compatible manufacturers, resellers, and distributors (PCMs).

BRIEF BACKGROUND ON DISK ARRAYS

The main technical components of a disk array are: (1) a set of disk drives; (2) configuration of the drives into some kind of interdependent system; (3) the interconnect protocols in the system; (4) the storage controller; and (5) the system cache architecture. The business of disk arrays appears even more complicated because arrays are sold with varying degrees of completeness (Disk/Trend, 1998). A number of companies sell subsystems (complete arrays ready to use), but product groups also include boards (array controllers, power supplies and other components without disk drives), and software (an individual software product providing array functionality). Thus, companies may specialize in boards or software, or they may provide complete systems. Companies may also be independent providers or captive producers making arrays for their own computer systems.

Pinning down the exact first appearance of disk array technology proves difficult. The technology originates in the idea of redundant, or fail-safe, computing when on-line transaction processing began to emerge in the 1960s, and multiple disk drives were bundled with computer systems for which they were specifically designed. Yet, companies were slow to offer fail-safe disk storage products that worked with a variety of computers, making a market for disk drive arrays slow to develop. As background, we provide a timeline of key developments regarding the history of disk arrays in Appendix A.

The market for disk arrays is segmented in a number of ways, and firms differ in the scope of their offerings. Arrays are sold in four identifiable primary markets: the computer mainframe array market (e.g., computer reservation systems), the network/midrange multi-user market (the bulk of the disk array market), the single user market, and the specialized high performance market (e.g., video servers, geophysical exploration data analysis). A disk array can have as few as two disk drives or as many as a couple of hundred; most arrays contain fewer than 100 drives.

During 1998, 134 companies offered array subsystems, boards or software at one time or another. However, three firms – IBM, EMC, and Compaq Computer – held almost three-quarters of the total market (Disk/Trend, 1999). Led by IBM and Compaq, captive sales accounted for almost two-thirds of industry revenue. EMC was the largest independent supplier, accounting for more than half of non-captive sales, followed by Data General and Hitachi Data Systems. U.S. firms held 90% of the market.

DATA AND METHODS

We use archival data on the disk array market to identify the complete set of firms that has ever offered a product on this market at any time. In testing the hypotheses, we use information on the times of market participation to estimate rate models of organizational founding and mortality. The independent variables consist of time-varying measures of the number of organizations in the market (density) by entry mode (*de novo/de alio*), the number of products on the market (product density), and several important geographically-based density counts from places with a related identity (the Boston Area, the San Francisco Bay Area, and California). We also include a number of time-varying control variables in the models to help rule out alternative interpretations. These include: firm tenure in the market; public/private company status; number of products; product submarkets; product distribution channels; firm size; membership in an industry association; venture capital recipient; population age at entry; density; density at founding; venture capital funding of industry; density of industry association, and industry revenue. We describe below sources and metrics of the variables.

Data sources on disk array producers

The data analyzed here cover the complete set of disk array producers serving the market worldwide, dating from the Twincom product in 1986 through the end of 1998, the last year of full coverage from the most comprehensive source of data available. The data come primarily from Disk/Trend, Inc. Disk/Trend publishes annual reports on disk drive arrays, as well as other kinds of storage. The first Disk/Trend report on arrays was published in 1993. The reports cover every company that makes complete subsystems, boards, or software specifically intended to permit disk drives to operate as an array. The reports publish firm-level data on revenues and unit shipments for the largest firms in the industry and in a specific market segment; typically firm-level data cover 90% or more of revenues and unit shipments in the industry but represent only 20% of the total number of companies in the market. The reports also list specifications for each product a company ships and the date of its first shipment.

In addition, we compiled event histories for each company identified by Disk/Trend as an array manufacturer. These histories were generated by extensive library and online searches, which also turned up a few companies that made disk drive arrays prior to the publication of Disk/Trend. In some cases, the event histories revealed shipment dates that preceded those listed in Disk/Trend and provided more accurate dates for entry in and exit from the array market.

Entry and Exit of Array Producers. A firm's first date of product shipment signifies its entry in the array market. Determining organizational mortality or ending events, however, is less clear than with entry. For organizational mortality or ending events, the most important distinctions concern: (1) disbanding of the firm; (2) exit to another industry; and (3) merger or acquisition by another firm. The meaning of disbanding is unambiguous: the firm failed as a collective actor. Exit to another industry also suggests a lack of success in array manufacturing. The merger and acquisition ending events are harder to interpret. Although merger and acquisition both result in the loss of one or more organization, firms merge and are acquired for diverse reasons. Sometimes a firm flounders and its owners seek to recover some fraction of their investment by selling the firm. In other cases, a thriving firm's competencies command great value from potential acquirers or merger partners (Carroll and Hannan, 2000). Because of the ambiguous meaning of mergers and acquisitions, we base our analysis on the disbanding and exit to another industry, and consistent with standard practice treat mergers and acquisitions as censored.

We sometimes do not know exactly what happened to firms when they dropped from the set of producers; this is often the case when spells of array production were short and when scale of production was tiny. Our reading of the source materials and our knowledge of the market suggests to us that most exits of unknown type were disbandings or exits to other industries. So we treat these two events alike: the dependent variable in this analysis is disbanding/exit to another industry, defined to include events of unknown type. Firms known to have ended by other events (merger, acquisition) are treated as (non-informatively) censored on the right at the times of these events.

Firm-Level Variables

Dating Events and Measuring Organizational Age. The variable the organizations research literature labels "organizational age" is usually a measure of tenure in a particular organizational population. For the majority of array producers (212 of the 258 firms, or 83%), we know the exact annual quarterly date of entry and exit in the array market, based on product shipment. For the minority of array producers without quarterly entry and exit dates (17% of firms), we know the year of entry and exit and randomly assign quarterly dates within that year. Tenures in the disk array market were then calculated based on these quarterly entry and exit data.

De Novo/De Alio Status. We determined from the source materials whether a firm was a *de novo* or *de alio* producer. We use a dummy variable to indicate *de novo* status.

Public/Private Status. Using a variety of sources listing public companies, we attempted to identify every public firm in our database by year of operation. This dummy variable takes a value of one in the period when a company is listed as public and zero otherwise.

Number of Products. For each firm, we counted the number of distinct products on the disk array market in a given year.

Product Submarkets. We divided the market for disk arrays into four distinct product submarkets and record whether a firm sold a product in each of these. The submarkets are: single use, mainframe computer, networks, and high performance. Participation in each submarket is measured by a dummy variable.

Product Distribution Channels. We recorded whether the array producer was a captive firm, OEM (original equipment manufacturer) or PCM (a plug compatible manufacturer, reseller, and distributor). Preliminary analysis showed that the effects for OEM and PCM firm-level characteristics are similar and may be efficiently combined into a single dummy variable which we report in estimates below; captive array producers thus represent the omitted comparison for this dummy variable.

Firm Size. We measured organizational size as scale of operations, specifically the firm's annual revenue from its sale of arrays. For the major array producers in the market – i.e., the top 15 to 25 annual array producers, such as EMC, IBM, and DEC, which collectively represent approximately 90% of all annual industry revenue – we have precise firm-specific revenue data from Disk/Trend. For the few major producers that existed prior to Disk/Trend's coverage in 1992, we have linearly interpolated backwards the firm-specific revenues of their earlier annual spells, using their actual revenue trajectory post-1992 as the functional form for our imputation.

For the smallest and shortest-lived array producers, Disk/Trend does not publish firm-specific revenue figures, and we were unable to find more precise disk array revenue figures for them from other sources. However, Disk/Trend records the annual aggregate revenue of these non-major, smaller array producers based on their distribution channel used (captive, OEM, and PCM) and geographic location (companies based in the United States and those not in the United States). This corresponds to six different categories of aggregating smaller array producer revenue: smaller U.S. and non-U.S. captive array producer revenue, smaller U.S. and non-U.S. OEM array producer revenue, and smaller U.S. and non-U.S. PCM array producer revenue. Since we know which of these six different categories a smaller array producer is classified by Disk/Trend, we could impute an annual revenue for each smaller array producer, based on the average revenue for a firm in that category (i.e., total revenue in that category divided by the number of firms in that category).[8]

In exploratory models, we estimated models using the size variable in log form. In general, the findings are not greatly affected by this shift in specification. Because the log size specification amplifies differences among small firms and the data for these firms are less reliable, we believe the other specification is preferable.

Membership in Industry Association. We constructed a firm-specific time-varying dummy variable to indicate whether a firm was a member in the major industry association that operated within the disk array industry during the period under study, the RAID Advisory Board (RAB).

Venture Capital Recipient. We searched the SDC Platinum database constructed by Thomson Financial Securities Data and a variety of other sources listing companies that received venture capital to identify such firms in the disk array market. We use a dummy variable to indicate firms that received venture capital.

Population Age at Entry. We constructed a fixed firm-level variable that records the age of the organizational population at time of market entry. This variable takes the value of one in the first year of the disk array market and then increases in increments annually. It is intended as a control for possible effects of population aging, including first-mover or order-of-entry advantages in the disk array market.

Population-Level and Other Environmental Variables

Organizational Density. We used the life-history information on firms to construct a variety of density counts. These variables measure the total number of firms of a particular kind operating in any given year. We use in most models below a time-varying count of basic density, measuring all the firms in the market. We also use a time-invariant variable giving the density in the year of market entry for each firm (for justification of these specifications, see Carroll and Hannan 2000).

Focused Identity Densities. Tests of the theoretical proposition about perceptually focused identities are conducted with several different kinds of $N^P(t)$ density counts. First, we use the density of *de novo* producers to test Hypotheses 1a and 1b. We then look at the effects of several density variables based on geography to test Hypotheses 2a and 2b. We focus on the three locations where disk array producers agglomerate and there is a sense of place identity operative in the market—the Boston Area (Route 128) in Massachusetts, California, and the Bay Area in Northern California (which included mostly firms in "Silicon Valley" and a few firms just north or across the bay).[9] Finally, we examine the effects of density counts measuring *de novo* producers within specific geographical areas, e.g., California *de novo* producers and finally, most narrowly, the Bay Area *de novo* producers. These last density variables are appropriate for testing Hypotheses 3a and 3b.[10]

Product Density. We used the information on firms' annual product counts to construct product density counts. These variables measure the total number of products of a particular kind on the market in any given year. In models below, we use a time-varying count of product density, measuring all the products in the market.

Tests of the alternative theoretical proposition about products are conducted with several different kinds of product density counts. First, we use the product density of all producer firms to test Alternative Hypotheses 1a and 1b. We then look at the effects of several product density variables based on whether the product was destined for the OEM or PCM markets.

Percentage of Firms in RAB. We examine the effects of the percentage of array firms who are members of the RAB on rates of array producer entry and exit. In exploratory analyses, we used an alternative specification of the quarterly or annual density of RAB firms in lieu of the percentage of RAB members on rates of entry and exit; both specifications yield virtually identical estimates.

Venture Capital Array Funding. We recorded the total annual funding of disk array companies by venture capital firms based on the information we obtained from SDC Platinum database of Thomson Financial Securities Data.

Industry Revenue. For total industry revenue, we used Disk/Trend's figure of world-wide industry revenue from 1992 to 1998. For the period 1986 to 1992, prior to the establishment of Disk/Trend, we estimated industry revenue based on an exponential extrapolation from 1986 up to the exact 1992 industry figure. Our knowledge of the industry gives us a reasonable level of confidence in these early figures.

Summary. The collection effort revealed an abundance of firms entering the market in this short period. We were able to identify a total of 258 firms ever entering the market. This count begins in 1986 when Twincom enters with software for disk mirroring. It covers all firms known to offer disk arrays up to and including eleven new entrants in 1998: Acard Technology, ADI, Chaparral Network Storage, Creative Design Solutions, Engrows, Lexias, OneofUs, Sagitta, SMS Data Products Group, SoftRAID, and Synapsys Digital. Not unexpectedly, many of the array producers in our sample were small-scale and short-lived. Over the short history of the array market, there have been 114 disbanding/industry exits and 14 mergers/acquisitions.

Stochastic Model and Estimation

Founding/Entry Estimation. Consistent with standard frameworks for estimating rates of organizational entry/founding (see Carroll and Hannan, 2000), we estimate array producer entry using event-count models where the array market represents the unit at risk of experiencing an event. For this reason, entry models estimate the effects of population-level and environmental variables but not firm-level covariates. The entry models are based on quarterly counts of array producers entering the array market. Covariates are updated every quarter, the only exceptions being annual measures of industry revenue and venture capital array funding, where quarterly data are not available.

In order to estimate array entry rates, we explored both Poisson and negative binomial specifications. Exploratory analyses revealed the presence of overdispersion, where the variance of the event counts exceeds the mean (see Barron, 1992; Swaminathan, 1995), suggesting the appropriateness of the negative binomial form, which includes a parameter for overdispersion. For the negative binomial model, the relationship between the instantaneous rate of entry, λ_t, and a set of *j* covariates, Z_{jt}, is specified as: $\ln\lambda_t = \alpha + \sum_j \beta_j Z_{jt} + \varepsilon_t$, where α is the regression model constant, β_j are effects of covariates, and ε_t is the error term, which follows a gamma distribution. We estimated negative binomial regressions using the software package STATA.

<u>Exit/Disbanding Estimation</u>. We represent variation in the timing of disbanding/market exit as a piecewise-exponential function with breakpoints for the pieces denoted as $0 \le \tau_1 \le \tau_2 \le ... \le \tau_{\mathrm{p}}$. Assuming that $\tau_{\mathrm{p+1}} = \infty$, gives P periods: $\mathrm{I_p} = \{u \mid \tau_{\mathrm{p}} \le u \le \tau_{\mathrm{p+1}}\}$, p=1,...,P. After examining life tables and exploring estimates of a variety of choices of the breakpoints, we decided to break the duration scale (in years) at 2.0 and 4.0. With this choice, the first segment (0, 2.0] includes dated events that occur within the first 24 months in the industry along with cases that enter and exit at unknown times within the same year. The second segment (2.0, 4.0] includes dated events that occur within the second 24 months along with cases that enter at unknown time in one year and exit at unknown time in the next year. The final segment begins at four years and is open on the right.

We specify that the instantaneous disbanding/exit rate μ_i for organization *i* is a function of the form:

$$\ln\mu_i(u,t) = m_p + \gamma S_{it} + \beta N_{it} + \sum_k \delta_k X_{kit}, \qquad u \ge 0, u \in \mathrm{I_p}$$

where m_p denotes a set of tenure-specific effects, S_{it} denotes organizational size for firm *i* at time *t*, N_{it} denotes organizational density, and the *k* other time-varying covariates are summarized in X_{kit}. In basic tests of the hypotheses, we estimated models with this general form with the method of maximum likelihood as implemented with a user-defined routine in STATA (Sørensen, 1999). Estimation of rate models with time-varying covariates requires the construction of split-spell data whereby observed durations are artificially broken and censored at periodic points when the values of the covariates are updated. For exit models, we update values every year because the majority of the independent variables are based on annual not quarterly observations.

Tables 1 and 2 provide descriptive statistics for the variables used in both the entry and exit analyses.[11] Appendix tables B1 and B2 provide correlations among the key independent variables for entry and exit models.[12]

[Tables 1, 2 about here]

FINDINGS

Organizational Founding/Entry

Table 3 reports estimates of the founding/entry rate models for worldwide array producers.[13] Model 1 includes two variables measuring the resource environment for disk array production, the annual worldwide revenue generated by the disk array market and the annual amount of venture capital investment in disk array producers. It also includes the effects of array producer density.[14] In this model, array producer density significantly increases array producer entry, as does the amount of venture capital funding for the industry.

[Table 3 about here]

In Model 2, we disaggregate array producer density into separate density counts of *de novo* and *de alio* firms in order to test Hypothesis 1a. Hypothesis 1a predicts that organizational founding rates are positively related to initial increases in the density of the focused-identity *de novo* producers. As predicted by Hypothesis 1a, estimates in Model 2 reveal that the density of *de novo* array producers drives entry into the disk array market, while *de alio* density has a negative but non-significant effect on entry (see Appendix D1 for the quadratic specification of this model). Venture capital funding loses its significance here. This finding suggests that the positive effect of *de novo* density on entry is not driven by venture capital investments in the industry.

In Model 3, we again examine the effects of all array density on entry by adding the annual percentage of firms in the RAB and the annual density of products in the array market in order to estimate alternative theories of the development of the disk array organizational form. In this model, the density of all array producers no longer has a significant effect on rates of entry. In addition, the density of array products in the market shows no significant effect on firm entry. Thus, Alternative Hypothesis 1a, which predicts that entry rates increase with increasing density of products associated with a particular activity, is not supported. Moreover, the percentage of firms in the RAB significantly reduces entry, contrary to predictions based on institutional theory.

In Model 4, we use a specification similar to that for Model 3 but once again examine the effects of *de novo* and *de alio* density on entry. In support of Hypothesis 1a, *de novo* density continues to significantly increase array entry. The density of *de alio* firms continues to have a non-significant negative effect on entry. In addition, the density of array products in the market also has a non-significant effect on firm entry, offering no support for Alternative Hypothesis 1a. In this specification, the percentage of firms in the RAB has a negative but non-significant effect on firm entry.

Lastly, in Model 5, we estimate an alternative specification of product density by focusing on the density of products exclusively targeting the OEM or PCM disk array market. In this model, *de novo* density continues to have a significant effect in increasing array entry, but the density of products for the OEM or PCM market has a non-significant positive effect on entry.[15]

Overall, the effects of *de novo* density are strong and robust with respect to model specification. For illustration, when density of *de novo* firms reaches its mean value of 12 organizations, the entry rates of firms into the disk array market increase by approximately 8 times, suggesting an 800% increase in entry rates due to this variable. In contrast, predicted (non-significant) density of *de alio* firms has hardly any effect on firm entry rates.

In Table 4, we examine the general effects of geographic agglomeration (in the Boston Area, California, and the San Francisco Bay Area) and the role of geographically agglomerated *de novo* producers (in these same areas) on all entry rates (without regard to location). Models 6 through 8 test Hypothesis 2a, which predicts that the density of geographically agglomerated producers drive form development through increased entry rates.

[Table 4 about here]

In Model 6, the density of firms in the Boston Area is significantly correlated with increased entry rates, while the density of all other firms outside of Boston has a negative non-significant effect on entry. In Model 7, the density of California firms significantly increases entry rates, while the density of firms outside of California significantly reduces entry rates. Estimates in Model 8 show that the density of Bay Area array producers, and not firms outside of the Bay Area, significantly increases entry rates. Therefore, models 6 through 8 offer strong support for the role of geographic agglomeration in organizational form development (Hypothesis 2a).[16]

Figure 2 plots the predicted significant effects of densities of geographically agglomerated producers on firm entry rates based on Models 6, 7 and 8. The figure shows that firm density in the Boston Area has the strongest positive effect on al firm entry, followed by the Bay Area density and then California density. For example, when density in the Boston Area reaches 10 firms, it increases entry rate into the disk array market by about 8 times (800% increase). To reach the same level of increase in entry rates, the Bay Area density has to approach 13 firms, whereas California density has to approach 15 firms. The density of producers outside of California decreases entry rates practically to zero when it reaches about 20 firms.

[Figure 2 about here]

Models 9 through 11 examine the role of geographically agglomerated *de novo* producers in increasing overall rates of entry (Hypothesis 3a). In Model 9, contrary to Hypothesis 3a, the density of *de alio* firms in Boston, and not *de novo* Boston firms, drive array form development by significantly increasing entry rates. In this model, Boston *de novo* density has a positive but non-significant effect on firm entry.[17] In Model 9, we believe that the positive effects of Boston *de alio* density on array producer entry rates may be related to their role in geographic agglomeration. The density of Boston area firms increases array producer entry rates (see Model 6 and Figure 2), confirming Hypothesis 2A. Since Boston de alio firms constitute an overwhelming proportion of Boston area firms -- on average, there are about 14 times as many *de alio* to *de novo* firms in Boston, with very few Boston *de novo* firms (a maximum of 1 firm in a quarter) -- it is not surprising that Boston *de alio* firms might also generate a positive effect on entry rates given the effects of geographic agglomeration. However, as we later show, the substantive effect of Boston *de alio* density in increasing array producer entry rates is lower than with all other (non-Boston) *de novo* density counts.

In Model 10, however, the density of California *de novo* producers significantly increases entry rates, while California *de alio* firms has no significant effect on entry; non-California firms continue to significantly reduce entry. This pattern is consistent with Hypothesis 3a. Similarly, in Model 11, Bay Area *de novo* firms significantly increase entry rates, consistent with Hypothesis 3a, while Bay Area *de alio* firms do not have a significant effect on entry. Models 9 through 11 offer general support for the role of geographically agglomerated *de novo* producers in spearheading organizational form development.

Figure 3 plots the estimated significant effects of densities of geographically agglomerated *de novo* and *de alio* producers based on Models 9, 10 and 11. Figure 3 shows that although the density of *de alio* firms in the Boston Area significantly increases entry rates, this effect is much weaker than the positive effects on entry by either the Bay Area *de novo* firms or California *de novo* firms. The density of Bay Area *de novo* firms shows the most powerful positive effect on entry rates. For example, when Bay Area *de novo* density reaches 6 firms, the entry rates increase 30 times (3000% increase). To reach the same increase in entry rates, California *de novo* density has to approach 8 firms, whereas Boston Area *de alio* density has to approach 15 firms.

[Figure 3 about here]

Organizational Disbanding/Exit

In Table 5, we turn to estimates of array producer disbanding/exit.[18] Model 12 offers a baseline of the key firm-specific and industry-level factors affecting firm exit. Firm size and OEM/PCM status significantly reduce firm exit, while firm-tenure in the market is significantly correlated with increased exit. In this baseline model, being a *de novo* firm, worldwide array market revenue, and a firm's density at founding have non-significant effects on exit rates.[19]

[Insert Table 5 about here]

Model 13 introduces the effects of organizational density on array exit rates by adding the density of all array producers to the baseline model. In this model, the density of array producers has a significant positive effect on firm exit, contrary to typical density-dependent models. The competitive effect of increasing array density on firm exit supports our earlier speculation that existing theories of organizational form emergence may not fully explain the evolution of organizational forms in the array market. Model 14 tests the focused-identity hypothesis of organizational form development for exit events (Hypothesis 1b): a legitimated organizational form emanates from the density of producers with perceptually focused identities in a market, such as *de novo* array producers, rather than total density, leading to the lowered mortality of all firms in this market. In this model, the density of *de novo* firms has a significant negative effect on firm exit, which supports Hypothesis 1b; the density of *de alio* firms has the opposite effect of significantly increasing firm exit.

To test the robustness of our support for Hypothesis 1b, Model 15 adds a host of additional firm-specific and industry-level factors potentially affecting firm exit. In this model, the number of products offered by a firm significantly reduces firm exit. Many of these other factors, including the different markets targeted for a firm's products (single, mainframe, network, or high performance usage), being a RAB member, the public status of the firm, whether the firm ever received venture capital funding, the amount of venture capital investment in disk array firms, and entering the array market at a later date, however, show no significant effects on exit rates.[20] Moreover, this model still strongly supports Hypothesis 1b even after controlling for all these factors: *de novo* density significantly reduces firm exit, while *de alio* density significantly increases firm exit. The absence of a strong significant effect of venture capital investment on exit rates indicates both that venture capital investment does not prevent firms from exiting the disk array market and that the beneficial effect of *de novo* density on exit rates is independent of venture capital investment in this industry.

Model 16 continues to test the robustness of our findings in support of Hypothesis 1b by examining two alternative explanations for the legitimation of an organizational form: the involvement of firms in trade associations (i.e., the RAB) and the density of products offered in the market. In Model 16, controlling for the annual percentage of firms in the RAB and the annual density of products in the array market, *de novo* density continues to significantly reduce exit rates, supporting Hypothesis 1b. Interestingly, although the density of array products has a non-significant (though positive) effect on exit rates, the percentage of firms in the RAB is significantly correlated with increased exit rates. (As with the entry models, an alternative measure of RAB density yields virtually identical estimates as percentage of RAB firms). Lastly, Model 17 estimates the alternative specification of density of products exclusively targeting the OEM/PCM market. In this model, *de novo* density continues to have a significant effect in reducing array exit, supporting Hypothesis 1b. The density of products in the OEM/PCM market shows no significant effect on exit, offering no support for Alternative Hypothesis 1b. (As with the entry models, alternative measures of OEM/PCM product density yield virtually identical estimates.)

Table 6 examines the general effects of geographic agglomeration (in the Boston Area, California, and the Bay Area) and the role of geographically agglomerated *de novo* producers (in these same geographic areas) on exit rates. Models 18 through 20 test Hypothesis 2b, which predicts that the density of geographically agglomerated producers drive form development through reduced exit rates.

[Table 6 about here]

In Model 18, the density of firms in the Boston Area significantly reduces exit rates, while the density of firms outside of Boston significantly increases exit rates, supportive of Hypothesis 2b. In Model 19, neither the density of California firms nor the density of firms outside of California significantly affects exit rates. In Model 20, Bay Area firms have a non-significant effect in decreasing array producers exit.[21] Density of firms outside of the Bay Area, however, significantly increases firm exit. Overall, Models 18-20 offer mixed support for the role of geographic agglomeration in reducing firm exit rates (Hypothesis 2b).[22]

Models 21 through 23 examine the role of geographically agglomerated *de novo* producers in reducing exit rates (Hypothesis 3b). In Model 21, both Boston Area *de novo* density and Boston Area *de alio* density significantly reduce disk array producer exit, while the density of firms outside of Boston significantly increases producer exit. Similarly, in Model 22, both California *de novo* density and California *de alio* density significantly reduce firm exit, while non-California density significantly increases exit rates. Lastly, in Model 23, both Bay Area *de novo* density and Bay Area *de alio* density significantly reduce exit, while the density of firms outside of the Bay Area significantly increases exit. Models 21 through 23 generally support the role of geographically agglomerated *de novo* firms in organizational form development through reduced exit rates (Hypothesis 3b).

In Models 21 through 23, densities of *de alio* firms in these geographically concentrated areas also reduce firm exit. However, the magnitude of agglomerated *de alio* density effects is substantively smaller than those of geographically agglomerated *de novo* firms.[23] Based on unreported multiplier rate calculations, the effect of the Boston Area *de novo* firms on reducing exit rates is 1.4 times stronger than that of the Boston Area *de alio* firms, the effect of California *de novo* firms on reducing exit rates is 2.7 times stronger than that of California *de alio* firms, and the effect of the Bay Area *de novo* firms on reducing exit rates is 3.8 times stronger than that of the Bay Area *de alio* firms. Figure 9 visually demonstrates the much greater power of geographically agglomerated *de novo* firms as compared to geographically agglomerated *de alio* firms in reducing exit rates, using firms agglomerated in the Bay Area as an example (based on Model 23). Figure 4 shows that it takes 3 *de novo* firms operating in the Bay Area to reduce exit rates practically to zero, whereas about 10 *de alio* firms operating in the Bay Area are required to reach the same effect on exit rates.

[Figure 4 about here]

DISCUSSION

Disk array production may never become an organizational form, as defined by an external identity code. Indeed, the trend in the last year or so has been for market analysts, the trade press, and the companies themselves to treat disk arrays as one element in a storage network, along with software, tape drives, switches, and routers. Although disk arrays underpin these networks, "data storage" may become the external identity that spawns an organizational form. If so, it would invoke a different set of identity rules on firm behavior and appearance; it would also include a much more diverse set of technologies and associated business firms.

Notwithstanding this possibility, we think the findings here demonstrate a potentially useful approach for analyzing how and where identity-based organizational forms emerge. We have made two claims about perceptually focused identities that empirical analysis supports: (1) the legitimation of an organizational form emanates from the number of *de novo* firms in a market; and (2) a large number of *de novo* firms *within* a geographic agglomeration possessing a related identity will accelerate the identity formation process. This amounts to re-specifying the density-dependent process currently thought to lead to an organizational form.

The findings for the density of *de novo* firms in disk array production support the claim about perceptual focus, since in this market *de alio* firms come from diverse origins and often retain significant activities in those areas while *de novo* firms tend to focus on disk arrays. All other things equal, an identity is more likely to be perceived and thus to gel into a recognizable form faster—and at lower levels of density—when the constituent organizations possess similar unit identities themselves than when they are heterogeneous. Such a development might be spurred by both intra- and extra-industry processes. Among a set of organizations, a common structure means that firms are likely to rely on common resources of labor, customers and the like. They are also more likely to identify with each other, recognize common interests and develop solidarity. Externally, the common features among *de novo* firms means that outsiders can more readily see the unit character in the grouping of firms and act accordingly.

The findings for agglomeration speak to social science's broad acceptance that organizational activity tends to be spatially concentrated. Economists, regional scientists, industrial sociologists and economic geographers generally agree that economic benefits accrue to firms that cluster (Becattini, 1990; Porter, 1990; Krugman, 1991; Storper, 1995; Hayter, 1997; Sorenson and Stuart, 2001) and that these benefits—agglomeration effects—increase with the number of firms in the cluster (Arthur, 1986). Agglomerations may enhance innovation, improve operational efficiency and stimulate economic growth through information spillovers, labor market pooling, the availability of specialized suppliers tailored to the industry, and a spirit of rivalry among competing firms that, in turn, enhances learning (Saxenian, 1991, 1994; Jaffe, Trajtenberg, and Henderson, 1993; Feldman, 1994; Head, Ries, and Swenson, 1995; McKendrick, Doner, and Haggard, 2000).

In a narrow sense, our findings agree with these positive evaluations of agglomeration. But they also suggest, as others have argued (Carroll and Wade, 1991; Swaminathan and Wiedenmayer, 1991; Lomi, 1995), that agglomeration might be a more general factor shaping the evolution of organizational populations, in this case the emergence of an organizational form. Ecologists have long hinted that the level of spatial aggregation implicitly defines the population boundaries, and that organizations' resource requirements generally have a geographic basis (Hannan and Freeman, 1989).

Our findings show that the level of analysis is indeed an important factor in determining how an institutionalized organizational form emerges. Despite possible appearances to the contrary, our findings are also largely consistent with the prior theories about legitimation and geography: whereas the Hannan et al. (1995) story about legitimation operating on a broader geographic scale applies to the spread of established organizational forms to new populations, the story developed here concerns the initial emergence of a form in any population.

Moreover, in developing the theoretical arguments, we have further modified the specification of the density-dependent process to incorporate particular locations explicitly. If a potential disk array form does get perceived and coheres, it may result not only from the number of *de novo* producers in a market, but from the number of *de novo* producers that are also geographically clustered in a place with a related identity. The core idea is that propinquity of *de novo* firms within a place with a related social identity may engender awareness of the potential form and make it more visible and salient to external evaluators. Additionally, the perception that organizations derive public cognitive recognition from clustering can even override to some extent the diffuse identity of *de alio* firms to create a sense of homogeneity and generate solidarity. Although (consistent with our theory) *de novo* firms have a considerably stronger effect than *de alio* firms on lowering exit rates, our findings suggest form emergence may be even more strongly related to geographic clustering than we theorized initially. Indeed, a market composed of geographically dispersed organizations may make it difficult for diverse actors to recognize and act on their commonalities; it may also make it harder for outsiders to see and identify the form, especially if they are engaged only in captive production. Moreover, the initial steps of identity-generation may be highly localized, but the process spreads quite rapidly across geographic boundaries. In disk arrays, an increase in the number of agglomerated firms in the Bay Area and Boston region reduced the exit rates for *all* firms in the market; disk array firms in Taiwan and Europe benefited from the legitimation process in the U.S.

In terms of future research, the findings suggest several avenues. One emerges from a limitation of our study noted by one of the reviewers, namely that we do not examine the actions of external agents. Although we used what financial analysts and market participants wrote and said about the market to develop our theory, we did not systematically study them. Obviously, attending more carefully to how outsiders classify organizations can bear fruit (Zuckerman 1999, 2000; Zuckerman and Kim 2003). The salient bases of identity are likely to be quite different for different external audiences (Philips and Zuckerman 2001). If codes are enforced differently from place to place, researchers might need to tailor their typologies of organizational form to the specific locale and social context under study. Baron (2002) speculates that different kinds of informants are likely to classify organizations along dimensions that do not correspond to product markets. More systematic analysis of relevant outsiders could contribute to a better understanding of form emergence. Human resource officers or recruiters or even potential employees, for example, give greater importance to an organization's labor market identity (Baron 2002). Hsu and Podolny (2002) use content analysis of movie reviews to determine how films and genres can be classified, an approach that could be used to classify firms and their identities. There is certainly room for more research on how external agents perceive organizational identities.

A second area could focus on the ecological consequences of delineating identities based on labor market versus product market considerations (Baron 2002). In fact, Baron and Hannan (2002) find evidence that organizations that establish a labor market identity prior to a product market identity were less likely to alter their labor market model over time than were organizations that were product-driven.

Finally, a final note regarding the role played by geography in the development of organizational forms seems important to consider in future research. Those who study organizations and geography appear to us to characterize agglomeration, at least implicitly, in two ways. One approach treats agglomerations in largely functional terms—as places where close proximity in input-output relations confers economic benefits such as economies of scale, innovation, and economizing on transaction costs. A second more sociological view characterizes agglomerations as places with social identities of their own, independent of any single market cluster. Are the transactional qualities of agglomerations or the social identities of place more relevant to form emergence?

We cannot answer for certain, and found evidence that suggests both processes operate in the disk array market. In support of the view that an agglomeration's functional attributes may contribute to form emergence, for example, is the difference in the magnitude of positive effects on entry rates that appear to reflect the physical proximity of geographical clustering: the Boston Area (with the largest effect) is more compact than the Bay Area, and the Bay Area is a subset of California. But we also find it intriguing that our findings are associated with two locations with strong identities of place—Route 128 and Silicon Valley. Both places have related identities recognized by the market participants and external agents. Compared with other locations, they likely have denser direct and indirect interaction patterns with their resident organizations, thereby providing more focus to outsiders' perceptions. But we leave this as speculation and encourage researchers to address each possibility.

Figure 1. Counts of Business Press Usage of Various Possible Identity Form Labels

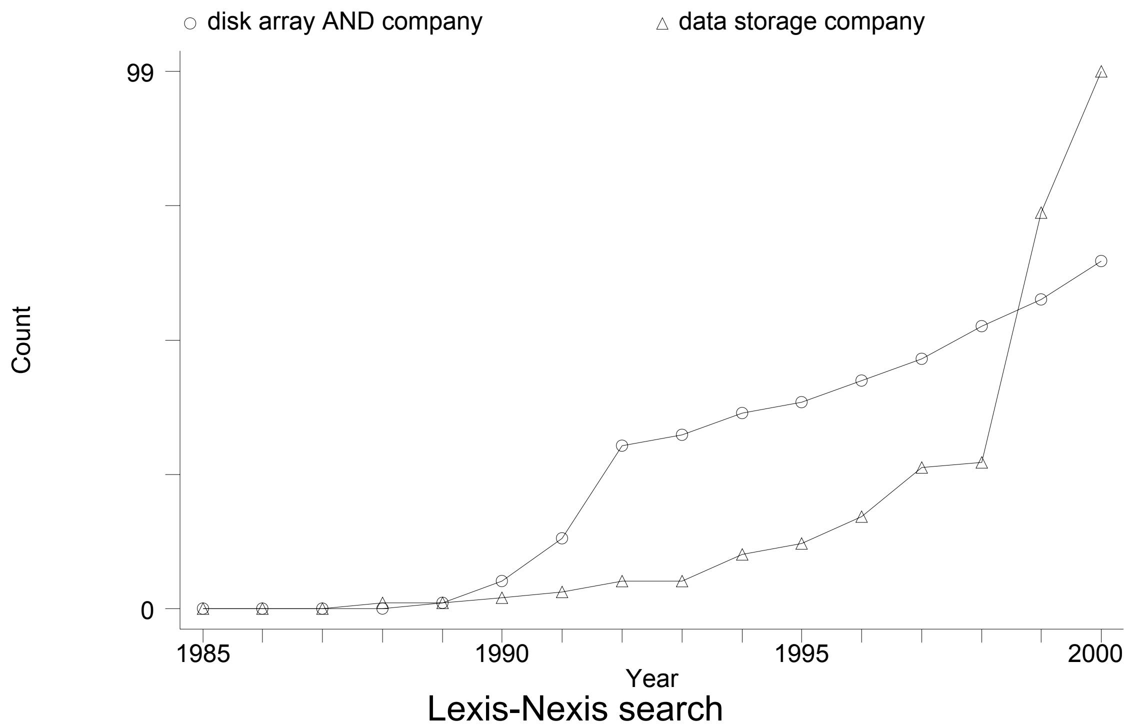

Figure 2. Effects of Densities of Geographically Agglomerated Firms on All Firm Entry Rate into the Disk Array Market

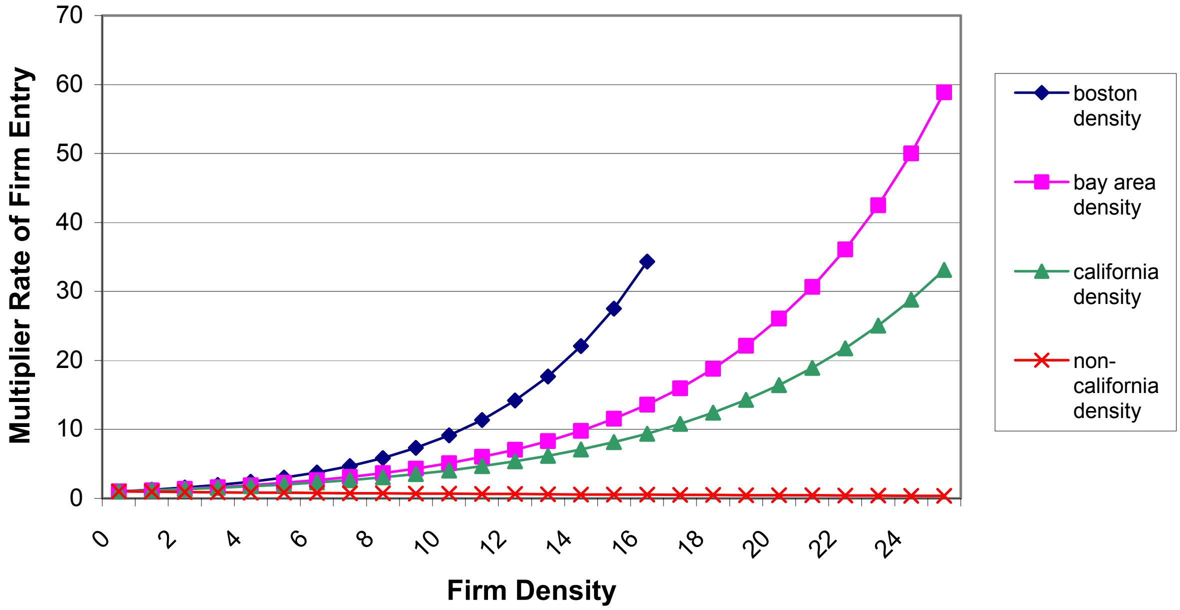

Figure 3. Effects of Densities of Geographically Agglomerated *De Novo* and *De Alio* Firms on All Firms Entry Rates into the Disk Array Market

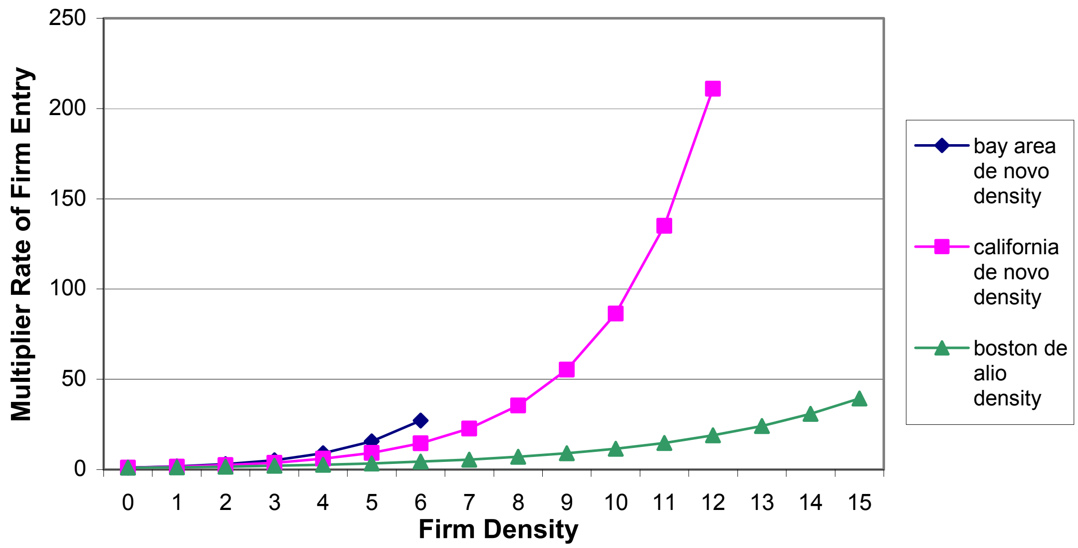

Figure 4. Effects of Densities of Bay Area *De Novo* and Bay Area *De Alio* Firms on All Firm Exit Rate

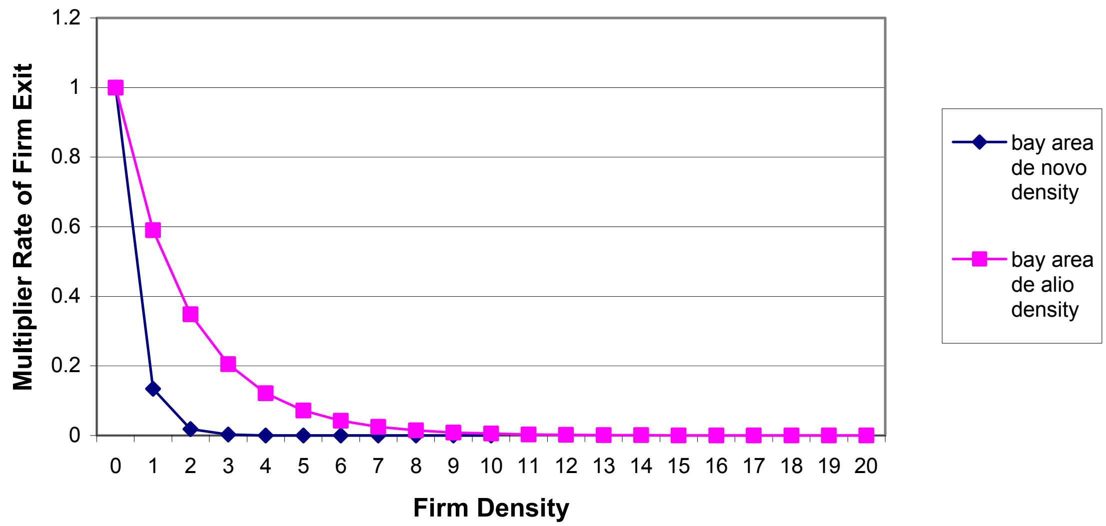

Table 1. Descriptive Statistics for Disk Array Producer Entry/Founding Models

Variable	Obs	Mean	Std. Dev.	Min	Max
Industry Revenue/1000 (t)	51	4.40	4.92	.003	12.6
Venture Capital Array Funding/1000 (t)	51	15.5	19.0	0	59.3
Density of All Firms (t-1)	51	79.8	65.0	0	180
Density of *De Novo* Firms (t-1)	51	12.3	9.06	0	27
Density of *De Alio* Firms (t-1)	51	67.5	56.2	0	158
Percentage of Firms in RAB (t-1)	51	.080	.092	0	.217
Density of Products (t-1)	51	187.1	168.7	0	475
Density of Products for the OEM/PCM market (t-1)	51	144.2	133.7	0	392
Density of Firms Outside Boston Area (t-1)	51	71.2	59.5	0	165
Density of Boston Area Firms (t-1)	51	8.59	5.79	0	16
Density of Firms Outside California (t-1)	51	51.8	43.4	0	117
Density of California Firms (t-1)	51	28.0	21.8	0	63
Density of Firms Outside Bay Area (t-1)	51	66.7	56.0	0	153
Density of Bay Area Firms (t-1)	51	13.1	9.21	0	27
Density of Boston Area *De Novo* Firms (t-1)	51	.549	.503	0	1
Density of Boston Area *De Alio* Firms (t-1)	51	8.04	5.36	0	15
Density of California *De Novo* Firms (t-1)	51	5.43	3.53	0	11
Density of California *De Alio* Firms (t-1)	51	22.5	18.4	0	54
Density of Bay Area *De Novo* Firms (t-1)	51	3.51	1.91	0	6
Density of Bay Area *De Alio* Firms (t-1)	51	9.61	7.42	0	21

N of firm entries/foundings = 258; N of *de novo* firm entries = 45; N of *de alio* firm entries = 213
N of spells = 51 quarters

Table 2. Descriptive Statistics for Disk Array Producer Disbanding/Exit Split-Spell File

Variable	Obs	Mean	Std. Dev.	Min	Max
OEM or PCM Firm =1	1219	.819	.385	0	1
De Novo Firm =1	1219	.153	.361	0	1
Size of Firm (t)	1219	49.6	274.2	.105	3517.2
Industry Revenue/1000 (t)	1219	7.32	4.25	.003	12.6
Density Delay All Firms (u_0)	1219	74.7	58.7	0	189
Density of All Firms (t)	1219	138.5	56.2	0	189
Density of *De Novo* Firms (t)	1219	21.8	6.01	0	29
Density of *De Alio* Firms (t)	1219	127.7	41.1	1	165
Number of Products for Firm (t)	1219	3.72	4.29	0	36
Publicly Traded Firm =1 (t)	1219	.267	.442	0	1
RAB Member =1 (t)	1219	.162	.368	0	1
Venture Capital Recipient =1	1219	.039	.195	0	1
Firm Offers Single Use Product =1 (t)	1219	.130	.336	0	1
Firm Offers Mainframe Product =1 (t)	1219	.057	.233	0	1
Firm Offers Network Product =1 (t)	1219	.879	.327	0	1
Firm Offers High Performance Product =1 (t)	1219	.066	.248	0	1
Venture Capital Array Funding/1000 (t)	1219	15.0	16.2	0	59
Population Age at Entry (u_0)	1219	6.93	2.30	1	13
Percentage of Firms in RAB (t)	1219	.162	.065	0	.217
Density of Products (t)	1219	584.9	218.9	1	763
Density of Products for the OEM/PCM market (t)	1219	214.0	81.9	1	299
Density of Firms Outside Boston Area (t)	1219	135.6	43.1	1	173
Density of Boston Area Firms (t)	1219	13.9	3.13	0	18
Density of Firms Outside California (t)	1219	95.9	30.2	1	122
Density of California Firms (t)	1219	53.6	15.6	0	68
Density of Firms Outside Bay Area (t)	1219	124.9	39.7	1	160
Density of Bay Area Firms (t)	1219	24.5	6.49	0	31
Density of Boston Area *De Novo* Firms (t)	1219	1.11	.392	0	2
Density of Boston Area *De Alio* Firms (t)	1219	12.8	2.86321	0	16
Density of California *De Novo* Firms (t)	1219	8.97	2.28	0	11
Density of California *De Alio* Firms (t)	1219	44.6	13.9	0	58
Density of Bay Area *De Novo* Firms (t)	1219	5.67	1.01	0	7
Density of Bay Area *De Alio* Firms (t)	1219	18.8	5.91	0	26

N of all firms = 258; N of *de novo* firms = 45; N of *de alio* firms = 213
N of firms' exits = 114 (including acquisitions 128); N of *de novo* firms' exits = 14(17); N of *de alio* firms' exits = 100(111)
N of firm-years = 1219, N of *de novo* firm-years = 187; N of *de alio* firm-years = 1032

Table 3. ML Estimates of Negative Binomial Models
of Founding/Entry Rates of Disk Array Producers, 1986 to 1998
(Standard errors shown in parentheses)

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Constant	.365	.123	.342	.146	.092
	(.246)	(.245)	(.246)	(.245)	(.247)
Industry Revenue/1000 (t)	-.218***	-.307***	-.057	-.183**	-.231***
	(.041)	(.045)	(.079)	(.079)	(.076)
Venture Capital Array Funding/1000 (t)	.017***	.008	.015***	.007	.007
	(.006)	(.006)	(.006)	(.005)	(.006)
Density of All Firms (t-1)	.021***		.013		
	(.003)		(.010)		
Density of *De Novo* Firms (t-1)		.198***		.185***	.187***
		(.051)		(.052)	(.055)
Density of *De Alio* Firms (t-1)		-.0001		-.013	.002
		(.007)		(.012)	(.013)
Percentage of Firms in RAB (t-1)			-10.5*	-7.34	-5.16
			(4.66)	(4.21)	(4.30)
Density of Products (t-1)			.004	.005	
			(.004)	(.003)	
Density of Products for the OEM/PCM market (t-1)					.0007
					(.004)
N of Observations	51	51	51	51	51
Dispersion parameter	.272	.171	.219	.144	.158
Log Likelihood	-118.6	-113.3	-116.2	-111.1	-112.6
Chi Square vs. null (constant rate)	38.7	49.1	43.5	53.6	50.6
D.F.	3	4	5	6	6

*** p < .01; ** p < .025; * p < .05

Table 4. ML Estimates of Negative Binomial Models
of Founding/Entry Rates of Disk Array Producers, 1986 to 1998
(Standard errors shown in parentheses)

	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)
Constant	.252 (.240)	.182 (.247)	.212 (.240)	.211 (.247)	-.115 (.280)	-.228 (.318)
Industry Revenue/1000 (t)	-.015 (.073)	-.188* (.084)	-.052 (.070)	.003 (.075)	-.310*** (.093)	-.070 (.066)
Venture Capital Array Funding/1000 (t)	.001 (.007)	.007 (.006)	.007 (.006)	.001 (.007)	-.001 (.006)	.001 (.006)
Percentage of Firms in RAB (t-1)	-7.54 (4.31)	-4.87 (4.55)	-5.62 (4.42)	-8.16 (4.33)	-.079 (4.64)	-3.55 (4.21)
Density of Products (t-1)	.007 (.004)	.002 (.003)	.005 (.003)	.008* (.004)	.005 (.003)	.007* (.003)
Density of Boston Area Firms (t-1)	.221*** (.083)					
Density of Firms Outside Boston Area (t-1)	-.022 (.017)			-.025 (.017)		
Density of Boston Area *De Novo* Firms (t-1)				-.016 (.323)		
Density of Boston Area *De Alio* Firms (t-1)				.245*** (.088)		
Density of California Firms (t-1)		.140*** (.043)				
Density of Firms Outside California (t-1)		-.039* (.020)			-.047** (.018)	
Density of California *De Novo* Firms (t-1)					.446*** (.132)	
Density of California *De Alio* Firms (t-1)					.081 (.046)	
Density of Bay Area Firms (t-1)			.163*** (.047)			
Density of Firms Outside Bay Area (t-1)			-.021 (.014)			-.031* (.014)
Density of Bay Area *De Novo* Firms (t-1)						.550*** (.170)
Density of Bay Area *De Alio* Firms (t-1)						.099 (.051)
N of Observations	51	51	51	51	51	51
Dispersion parameter	.143	.156	.143	.138	.107	.108
Log Likelihood	-113.4	-111.8	-111.3	-113.1	-109.1	-108.6
Chi Square vs. null (constant rate)	49.0	52.2	53.21	49.6	57.7	58.6
D.F.	6	6	6	7	7	7

*** $p < .01$; ** $p < .025$; * $p < .05$.

Table 5. ML Estimates of Piece-wise Constant Rate Models of Disbanding/Exit of Disk Array Producers
(Standard errors shown in parentheses)

	Model (12)	Model (13)	Model (14)	Model (15)	Model (16)	Model (17)
Tenure: 0 < u <= 2	-1.94***	-2.87***	-1.81***	-1.71	-.093	-.145
	(.408)	(.566)	(.667)	(.967)	(1.00)	(.945)
Tenure: 2 < u <= 4	-1.64***	-2.49***	-1.34	-.947	.529	.467
	(.467)	(.603)	(.692)	(.963)	(1.02)	(.951)
Tenure: u > 4	-1.57***	-2.18***	-.682	.002	1.19	1.14
	(.547)	(.636)	(.772)	(1.01)	(1.06)	(.996)
OEM or PCM Firm = 1	-.681*	-.840***	-.759**	-.904***	-.944***	-.945***
	(.304)	(.315)	(.308)	(.345)	(.345)	(.344)
De Novo Firm = 1	-.245	-.137	-.053	-.137	-.087	-.090
	(.280)	(.281)	(.280)	(.299)	(.298)	(.298)
Size of Firm (t)	-.239**	-.253**	-.175*	-.123	-.120	-.123
	(.098)	(.106)	(.080)	(.070)	(.068)	(.070)
Industry Revenue/1000 (t)	.044	-.083	.131**	.109	.034	.185**
	(.043)	(.059)	(.057)	(.063)	(.106)	(.075)
Density Delay All Firms (u_0)	.005	.006**	.009***	.004	.004	.003
	(.003)	(.003)	(.003)	(.004)	(.004)	(.004)
Density All Firms (t)		.012***				
		(.004)				
Density of *De Novo* Firms (t)			-.198***	-.232***	-.538***	-.535***
			(.048)	(.056)	(.111)	(.121)
Density of *De Alio* Firms (t)			.022***	.024***	.010	.025***
			(.004)	(.005)	(.020)	(.008)
Number of Products for Firm (t)				-.177***	-.172***	-.173***
				(.066)	(.066)	(.066)
Public Firm = 1 (t)				-.294	-.265	-.264
				(.304)	(.307)	(.307)
RAB Member = 1 (t)				-1.86	-1.90	-1.89
				(1.02)	(1.02)	(1.02)
Venture Capital Recipient = 1				-.565	-.693	-.722
				(1.05)	(1.06)	(1.06)
Single Use Product = 1 (t)				.059	.013	.011
				(.370)	(.369)	(.370)
Mainframe Product = 1 (t)				-15.6	-16.0	-15.8
				(1232.3)	(1480.6)	(1298.9)
Network Product = 1 (t)				-.145	-.185	-.177
				(.421)	(.424)	(.426)
High Performance Product = 1 (t)				-1.26	-1.30	-1.28
				(.860)	(.859)	(.861)
Venture Capital Array Funding/1000 (t)				-.001	.006	-.009
				(.010)	(.013)	(.017)
Population Age at Entry (u_0)				.210	.148	.172
				(.140)	(.140)	(.144)
Percentage of firms in RAB (t)					30.8***	16.3
					(8.06)	(10.3)
Density of Products (t)					.005	
					(.005)	
Density of Products for the OEM/PCM market (t)						.010
						(.006)
N of Observations	1539	1539	1539	1539	1539	1539
N of Firms	258	258	258	258	258	258
N of Exit Events (does not include Acquisitions)	114	114	114	114	114	114
Log Likelihood	-249.6	-244.0	-233.3	-211.4	-202.0	-201.0
Chi Square vs. null (constant rate)	72.6	83.8	105.2	149.1	168.0	169.9
D.F.	7	8	9	19	21	21

*** $p < .01$; ** $p < .025$; * $p < .05$. Note: Exit event does not include acquisitions.

Table 6. ML Estimates of Piece-wise Constant Rate Models of Disbanding/Exit of Disk Array Producers
(Standard errors shown in parentheses)

	Model (18)	Model (19)	Model (20)	Model (21)	Model (22)	Model (23)
Tenure: 0 < u <= 2	-.660	-3.90**	-3.49*	-.705	.755	.230
	(.988)	(1.65)	(1.58)	(.985)	(1.00)	(.964)
Tenure: 2 < u <= 4	-.047	-3.39*	-3.00	-.104	1.39	.852
	(1.01)	(1.64)	(1.58)	(1.01)	(1.04)	(.993)
Tenure: u > 4	.557	-2.96	-2.54	.514	2.08	1.55
	(1.06)	(1.63)	(1.58)	(1.06)	(1.10)	(1.05)
OEM or PCM Firm = 1	-.937***	-.992***	-.993***	-.940***	-.973***	-.958***
	(.345)	(.344)	(.343)	(.345)	(.346)	(.345)
De Novo Firm = 1	-.101	-.147	-.153	-.105	-.111	-.099
	(.298)	(.299)	(.299)	(.298)	(.299)	(.298)
Size of Firm (t)	-.134	-.186	-.194	-.137	-.126	-.126
	(.078)	(.105)	(.109)	(.080)	(.072)	(.073)
Industry Revenue/1000 (t)	-.032	.089	.032	-.046	-.126	-.312**
	(.100)	(.120)	(.117)	(.101)	(.130)	(.138)
Density Delay All Firms (u_0)	.004	.005	.005	.004	.003	.003
	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)
Number of Products for Firm (t)	-.177***	-.188***	-.188***	-.177***	-.174***	-.173***
	(.066)	(.067)	(.067)	(.066)	(.066)	(.066)
Public Firm = 1 (t)	-.265	-.280	-.279	-.267	-.288	-.276
	(.306)	(.303)	(.303)	(.306)	(.308)	(.308)
RAB Member = 1 (t)	-1.88	-1.82	-1.81	-1.87	-1.88	-1.88
	(1.02)	(1.02)	(1.02)	(1.02)	(1.02)	(1.02)
Venture Capital Recipient = 1	-.662	-.277	-.284	-.662	-.548	-.738
	(1.07)	(1.05)	(1.05)	(1.07)	(1.05)	(1.07)
Single Use Product = 1 (t)	.042	.090	.090	.044	.059	.042
	(.370)	(.373)	(.375)	(.371)	(.373)	(.373)
Mainframe Product = 1 (t)	-15.0	-14.4	-14.4	-15.0	-15.7	-15.0
	(910.9)	(725.3)	(722.3)	(909.6)	(1312.1)	(898.8)
Network Product = 1 (t)	-.165	-.165	-.164	-.159	-.132	-.131
	(.423)	(.424)	(.426)	(.425)	(.428)	(.429)
High Performance Product = 1 (t)	-1.27	-1.28	-1.26	-1.26	-1.21	-1.22
	(.859)	(.868)	(.870)	(.860)	(.859)	(.859)
Venture Capital Array Funding/1000 (t)	-.016	.005	.007	-.016	.119***	.058**
	(.012)	(.018)	(.014)	(.011)	(.034)	(.026)
Population Age at Entry (u_0)	.104	-.004	.012	.116	.172	.179
	(.135)	(.121)	(.123)	(.138)	(.144)	(.145)
Percentage of Firms in RAB (t)	34.5***	1.53	6.04	37.4***	10.9	12.9
	(9.64)	(4.91)	(6.29)	(11.0)	(5.74)	(8.06)
Density of Products (t)	-.037***	-.006	-.008	-.038***	.023***	-.015
	(.009)	(.005)	(.004)	(.010)	(.007)	(.008)
Density of Boston Area Firms (t)	-1.00***					
	(.236)					
Density of Firms Outside Boston Area (t)	.211***			.215***		
	(.049)			(.051)		
Density of Boston Area *De Novo* Firms (t)				-1.39*		
				(.688)		
Density of Boston Area *De Alio* Firms (t)				-.978***		
				(.245)		
Density of California Firms (t)		-.004				
		(.109)				
Density of Firms Outside California (t)		.058			.449***	
		(.048)			(.113)	
Density of California *De Novo* Firms (t)					-2.45***	
					(.232)	
Density of California *De Alio* Firms (t)					-.910***	
					(.232)	
Density of Bay Area Firms (t)			-.074			
			(.095)			
Density of Firms Outside Bay Area (t)			.061**			.211***
			(.026)			(.072)
Density of Bay Area *De Novo* Firms (t)						-2.01***
						(.502)
Density of Bay Area *De Alio* Firms (t)						-.528***
						(.181)
N of Observations	1539	1539	1539	1539	1539	1539
N of Firms	258	258	258	258	258	258
N of Exit Events (does not include Acquisitions)	114	114	114	114	114	114
Log Likelihood	-209.4	-219.8	-219.2	-209.2	-202.0	-201.5
Chi Square vs. null (constant rate)	153.2	132.3	133.6	153.5	167.9	168.8
D.F.	21	21	21	22	22	23

*** p < .01; ** p < .025; * p < .05. Note: Exit event does not include acquisitions

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Appendix A. Historical Summary of Developments in the Disk Drive Array Market

1956	First disk drive.
1965	First controller handling multiple drives (IBM 2314 DASF).
1966-70	Disk drives beginning to provide storage for on-line processing, which became the dominant mode in most systems. Reliability achieved through multiple copies stored on disk packs.
1971	The IBM 3330 Facility improved data integrity by extensive error detection and correction capabilities.
1976	First Tandem fault-tolerant computer shipped. Disk storage can be "mirrored."
1978	IBM receives U.S. patent for "System for Recovering Data Stored in Failed Memory Unit."
Mid-1980s	First hard disk subsystem used for the PC environment.
1986	Twincom ships first software disk array product.
1987	U.C. Berkeley "RAID" technical paper presented at conference.
1987	First shipment of a disk drive array or "cluster" using 5.25-inch disk drives.
1990	EMC offers the first disk array for mainframe storage that incorporates 5.25-inch disks. Its Symmetrix 4200 Integrated Cached Disk Array (ICDA) is a 24-gigabyte RAID system that replaces traditional 14” DASD disks.
1992	RAID Advisory Board established.
1997	Storage Networking Industry Association established.

Appendix B1. Correlations of Variables Used in Founding/Entry Analyses

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Industry Revenue/1000 (t)																			
2	Venture Capital Array Funding/1000 (t)	-.11																		
3	Density All Firms (t-1)	.86	-.08																	
4	Density *De Novo* Firms (t-1)	.91	.01	.97																
5	Density *De Alio* Firms (t-1)	.85	-.10	.99	.96															
6	Percentage of Firms in RAB (t-1)	.96	-.16	.91	.92	.90														
7	Density of Products (t-1)	.81	-.11	.98	.92	.98	.88													
8	Density of Products by OEM/PCM producers (t-1)	.83	-.14	.98	.92	.98	.89	.99												
9	Density of Firms Outside Boston Area (t-1)	.87	-.10	.99	.97	.99	.91	.98	.98											
10	Density of Boston Area Firms (t-1)	.75	.15	.95	.92	.95	.78	.92	.91	.94										
11	Density of Firms Outside California (t-1)	.86	-.11	.99	.96	.99	.90	.98	.98	.99	.95									
12	Density of California Firms (t-1)	.88	-.03	.99	.98	.99	.91	.97	.97	.99	.95	.99								
13	Density of Firms Outside Bay Area (t-1)	.87	-.10	.99	.97	.99	.91	.98	.98	.99	.94	.99	.99							
14	Density of Bay Area Firms (t-1)	.80	.05	.98	.96	.97	.83	.95	.94	.97	.97	.97	.98	.97						
15	Density of Boston Area *De Novo* Firms (t-1)	.66	.19	.81	.80	.80	.67	.81	.80	.80	.86	.80	.81	.80	.82					
16	Density of Boston Area *De Alio* Firms (t-1)	.74	.14	.95	.92	.95	.77	.92	.91	.94	.99	.95	.95	.94	.97	.84				
17	Density of California *De Novo* Firms (t-1)	.89	.12	.94	.97	.93	.86	.88	.88	.94	.94	.93	.96	.94	.94	.80	.94			
18	Density of California *De Alio* Firms (t-1)	.87	-.06	.99	.97	.99	.91	.98	.98	.99	.94	.99	.99	.99	.98	.80	.94	.94		
19	Density of Bay Area *De Novo* Firms (t-1)	.74	.21	.91	.92	.90	.75	.86	.85	.90	.96	.89	.93	.90	.95	.79	.96	.95	.91	
20	Density of Bay Area *De Alio* Firms (t-1)	.80	.00	.98	.95	.98	.84	.96	.94	.97	.96	.97	.98	.97	.99	.81	.96	.93	.98	.92

Appendix.B2. Correlations of Variables Used in Exit Analyses

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	OEM or PCM Firm =1															
2	*De Novo* Firm =1	.08														
3	Size of Firm (t)	-.23	-.06													
4	Industry Revenue/1000 (t)	.13	.01	.10												
5	Density Delay All Firms (u_0)	.29	-.00	-.15	.44											
6	Density of All Firms (t)	.16	-.03	.07	.86	.45										
7	Density *De Novo* Firms (t)	.16	-.02	.08	.84	.45	.87									
8	Density *De Alio* Firms (t)	.17	-.07	.02	.46	.34	.81	.73								
9	Number of Products for Firm (t)	-.16	-.07	.61	.19	-.18	.19	.20	.14							
10	Publicly Traded Firm =1 (t)	-.43	-.14	.13	.02	-.18	.01	.03	.01	.12						
11	RAB Member =1 (t)	-.04	-.03	.27	.14	-.08	.15	.17	.14	.54	.18					
12	Venture Capital Recipient =1	-.05	.48	-.02	-.01	-.07	-.04	-.04	-.07	-.04	.03	.06				
13	Firm Offers Single Use Product =1 (t)	.11	.10	-.07	.04	.12	.03	.02	.01	.05	-.16	-.09	-.03			
14	Firm Offers Mainframe Product =1 (t)	-.21	-.11	.33	.04	-.10	.01	.02	-.03	.23	.15	.22	-.05	-.10		
15	Firm Offers Network Product =1 (t)	.16	-.02	.06	.06	.06	.09	.11	.12	.14	.03	.14	.06	-.37	-.17	
16	Firm Offers High Performance Product =1 (t)	-.28	-.00	.04	-.10	-.23	-.11	-.12	-.11	.09	.13	.00	-.05	-.10	.05	-.44
17	Venture Capital Array Funding/1000 (t)	-.11	.04	-.01	-.33	-.20	-.56	-.38	-.61	-.08	.03	-.10	.04	-.04	.03	-.05
18	Population Age at Entry (u_0)	.23	.03	-.14	.45	.89	.46	.52	.39	-.17	-.12	-.06	-.06	.10	-.06	.07
19	Percentage of Firms in RAB (t)	.17	-.03	.07	.80	.44	.87	.94	.80	.19	.01	.18	-.05	.02	.01	.11
20	Density of Products (t)	.18	-.04	.06	.76	.44	.96	.90	.91	.19	.01	.16	-.05	.03	-.00	.11
21	Density of Products for the OEM/PCM market (t)	.17	-.05	.04	.57	.38	.78	.82	.85	.16	.00	.16	-.05	.01	-.01	.11
22	Density of Firms Outside Boston Area (t)	.17	-.07	.03	.55	.38	.86	.80	.99	.15	.01	.15	-.07	.01	-.02	.12
23	Density of Boston Area Firms (t)	.13	-.08	-.01	.09	.19	.47	.51	.85	.07	.03	.10	-.08	-.03	-.03	.12
24	Density of Firms Outside California (t)	.17	-.07	.03	.53	.37	.86	.78	.99	.15	.01	.15	-.07	.01	-.02	.12
25	Density of California Firms (t)	.17	-.07	.03	.51	.37	.83	.79	.99	.15	.01	.15	-.07	.01	-.02	.12
26	Density of Firms Outside Bay Area (t)	.17	-.07	.03	.56	.38	.87	.80	.99	.15	.01	.15	-.07	.01	-.02	.12
27	Density of Bay Area Firms (t)	.15	-.08	.01	.27	.28	.62	.66	.94	.11	.02	.13	-.08	-.01	-.03	.13
28	Density of Boston Area *De Novo* Firms (t)	.05	-.04	-.02	-.19	.01	-.04	.19	.35	.01	.03	.05	-.04	-.05	-.02	.07
29	Density of Boston Area *De Alio* Firms (t)	.13	-.08	-.01	.13	.21	.52	.53	.88	.08	.03	.11	-.08	-.03	-.03	.12
30	Density of California *De Novo* Firms (t)	.15	-.02	.08	.87	.45	.93	.94	.70	.19	.03	.15	-.04	.02	.02	.09
31	Density of California *De Alio* Firms (t)	.17	-.07	.02	.42	.34	.77	.73	.99	.14	.01	.14	-.07	.00	-.03	.12
32	Density of Bay Area *De Novo* Firms (t)	.10	-.04	.02	.31	.25	.59	.62	.66	.11	.04	.08	-.05	-.01	-.01	.08
33	Density of Bay Area *De Alio* Firms (t)	.15	-.08	.00	.25	.26	.58	.62	.92	.11	.01	.13	-.07	-.01	-.03	.13

Appendix B2. Correlations of Variables Used in Exit Analyses (Continued)

	Variable	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
17	Venture Capital Array Funding/1000 (t)	.06																
18	Population Age at Entry (u_0)	-.25	-.15															
19	Percentage of Firms in RAB (t)	-.12	-.57	.49														
20	Density of Products (t)	-.12	-.58	.47	.91													
21	Density of Products for the OEM/PCM market (t)	-.11	-.44	.42	.90	.87												
22	Density of Firms Outside Boston Area (t)	-.11	-.60	.42	.85	.95	.95											
23	Density of Boston Area Firms (t)	-.09	-.45	.28	.59	.61	.60	.81										
24	Density of Firms Outside California (t)	-.11	-.62	.41	.84	.94	.94	.99	.83									
25	Density of California Firms (t)	-.11	-.55	.42	.83	.93	.93	.99	.83	.99								
26	Density of Firms Outside Bay Area (t)	-.11	-.61	.42	.85	.95	.95	.99	.80	.99	.99							
27	Density of Bay Area Firms (t)	-.10	-.48	.36	.73	.78	.77	.92	.94	.93	.95	.91						
28	Density of Boston Area *De Novo* Firms (t)	-.04	-.22	.11	.29	.13	.10	.31	.72	.34	.36	.30	.60					
29	Density of Boston Area *De Alio* Firms (t)	-.09	-.47	.29	.61	.65	.64	.84	.99	.86	.86	.84	.95	.65				
30	Density of California *De Novo* Firms (t)	-.11	-.31	.50	.84	.89	.88	.77	.42	.76	.75	.78	.56	-.06	.47			
31	Density of California *De Alio* Firms (t)	-.11	-.57	.39	.79	.90	.90	.99	.86	.99	.99	.98	.97	.41	.88	.68		
32	Density of Bay Area *De Novo* Firms (t)	-.08	-.04	.34	.43	.63	.63	.67	.58	.66	.69	.67	.63	.07	.63	.72	.65	
33	Density of Bay Area *De Alio* Firms (t)	-.10	-.52	.34	.73	.75	.74	.90	.94	.90	.92	.89	.99	.65	.94	.49	.95	.52

Appendix C1. Sensitivity Analysis for Multicollinearity for Table 3.
Comparison of Reported Entry Estimates and Estimates with Deletion of Last Quarterly Observation[1]
(Standard errors in parentheses)

	Model		Model		Model		Model		Model	
	(1)	(A1)[2]	(2)	(A2)	(3)	(A3)	(4)	(A4)	(5)	(A5)
Density of All Firms (t-1)	.021***	.021***			.013	.013				
	(.003)	(.003)			(.010)	(.011)				
Density of *De Novo* Firms (t-1)			.198***	.242***			.185***	.218***	.187***	.224***
			(.051)	(.053)			(.052)	(.056)	(.055)	(.055)
Density of *De Alio* Firms (t-1)			-.0001	-.007			-.013	-.010	.002	.002
			(.007)	(.007)			(.012)	(.012)	(.013)	(.013)
Number of Observations	51	50	51	50	51	50	51	50	51	50
Log Likelihood	-.118.6	-117.2	-113.3	-.109.8	-116.2	-115.1	-111.1	-109.0	-112.6	-.109.0

*** p < .01; ** p < .025; * p < .05

[1] Although we report the key variables here, these models are based on the same full specification as in Table 3.

[2] Models that start with 'A' are based on the deletion of the last quarterly observation.

Appendix C2. Sensitivity Analysis for Multicollinearity for Table 4.
Comparison of Reported Entry Estimates and Estimates with Deletion of Last Quarterly Observation[1]
(Standard errors in parentheses)

	Model (6)	(A6)2	Model (7)	(A7)	Model (8)	(A8)	Model (9)	(A9)	Model (10)	(A10)	Model (11)	(A11)
Density of Boston Area Firms (t-1)	.221***	.236***										
	(.083)	(.085)										
Density of Firms Outside Boston Area (t-1)	-.022	-.027					-.025	-.030				
	(.017)	(.018)					(.017)	(.018)				
Density of Boston Area *De Novo* Firms (t-1)							-.016	.012				
							(.323)	(.323)				
Density of Boston Area *De Alio* Firms (t-1)							.245***	.259***				
							(.088)	(.090)				
Density of California Firms (t-1)			.140***	.152***								
			(.043)	(.046)								
Density of Firms Outside California (t-1)			-.039*	-.039*					-.047**	-.046**		
			(.020)	(.020)					(.018)	(.018)		
Density of California *De Novo* Firms (t-1)									.446***	.445***		
									(.132)	(.133)		
Density of California *De Alio* Firms (t-1)									.081	.090		
									(.046)	(.049)		
Density of Bay Area Firms (t-1)					.163***	.165***						
					(.047)	(.047)						
Density of Firms Outside BayArea (t-1)					-.021	-.020					-.031*	-.031*
					(.014)	(.014)					(.014)	(.014)
Density of Bay Area *De Novo* Firms (t-1)											.550***	.549***
											(.170)	(.170)
Density of Bay Area *De Alio* Firms (t-1)											.099	.101
											(.051)	(.052)
Number of Observations	51	50	51	50	51	50	51	50	51	50	51	50
Log Likelihood	-.113.4	-112.1	-.111.8	-110.4	-111.3	-110.2	-113.1	-.111.8	-109.1	-.107.9	-.108.6	-107.5

*** p < .01; ** p < .025; * p < .05

[1] Although we report the key variables here, these models are based on the same full specification as in Table 4

[2] Models that start with 'A' are based on the deletion of the last quarterly observation

Appendix D1. ML Estimates of Negative Binomial Models
of Founding/Entry of Array Producers with Squared Density Terms
(Standard errors shown in parentheses)

	Model (D1)	Model (D2)	Model (D3)	Model (D4)	Model (D5)	Model (D6)
Constant	-.004	-.327	-.275	-.119	-.270	-.267
	(.239)	(.283)	(.292)	(.275)	(.314)	(.310)
Industry Revenue/1000 (t)	-.197***	-.205***	-.192***	-.131	-.162	-.133
	(.031)	(.048)	(.072)	(.068)	(.090)	(.069)
Venture Capital Array Funding (t)	.003	-.002	-.002	-.003	-.012	-.004
	(.005)	(.005)	(.006)	(.006)	(.008)	(.005)
Density of All Firms (t-1)	.053***					
	(.007)					
Density of All Firms Squared/1000 (t-1)	-.202***					
	(.039)					
Density of *De Novo* Firms (t-1)		.415***	.420***			
		(.078)	(.097)			
Density of *De Novo* Firms Squared (t-1)		-.009***	-.009***			
		(.003)	(.003)			
Density of *De Alio* Firms (t-1)		-.007	-.020			
		(.006)	(.011)			
Percentage of Firms in RAB (t-1)			-.180	-.486	.186	.107
			(4.45)	(4.33)	(4.93)	(4.29)
Density of Products (t-1)			.004	.005	.005	.006*
			(.003)	(.003)	(.004)	(.003)
Density of Firms Outside Bay Area (t-1)				-.023		-.030*
				(.012)		(.013)
Density of Bay Area Firms (t-1)				.316***		
				(.073)		
Density of Bay Area Firms Squared (t-1)				-.006**		
				(.002)		
Density of Firms Outside Boston Area (t-1)					-.011	
					(.016)	
Density of Boston Area *De Novo* Firms (t-1)					.143	
					(.301)	
Density of Boston Area *De Alio* Firms (t-1)					.576***	
					(.142)	
Density of Boston Area *De Alio* Firms Squared (t-1)					-.026***	
					(.009)	
Density of Bay Area *De Novo* Firms (t-1)						.448***
						(.167)
Density of Bay Area *De Alio* Firms (t-1)						.251***
						(.090)
Density of Bay Area *De Alio* Firms Squared (t-1)						-.007*
						(.003)
N of Observations	51	51	51	51	51	51
Dispersion parameter	.085	.081	.075	.078	.097	.068
Log Likelihood	-108.6	-108.6	-107.6	-108.3	-109.3	-106.8
Chi Square vs. null (constant rate)	58.6	58.7	60.5	59.1	57.3	62.2
D.F.	4	5	7	7	8	8

*** p < .01; ** p < .025; * p < .05.

Appendix D2. ML Estimates of Piece-wise Constant Rate Model
of Disbanding/Exit of Disk Array Producers with Square Density Terms
(Standard errors shown in parentheses)

	Model (D7)
Tenure: $0 < u <= 2$	-.035 (.935)
Tenure: $2 < u <= 4$	.598 (.967)
Tenure: $u > 4$	1.30 (1.02)
OEM or PCM Firm = 1	-.952*** (.345)
De Novo Firm = 1	-.102 (.298)
Size of Firm (t)	-.126 (.073)
Industry Revenue/1000 (t)	.787*** (.203)
Density Delay All Firms (u_0)	.003 (.004)
Number of Products for firm (t)	-.174*** (.066)
Public Firm = 1 (t)	-.275 (.308)
RAB Member = 1 (t)	-1.88 (1.02)
Venture Capital Recipient = 1	-.782 (1.08)
Single Use Product = 1 (t)	.052 (.373)
Mainframe Product = 1 (t)	-15.0 (901.6)
Network Product = 1 (t)	-.112 (.430)
High Performance Product = 1 (t)	-1.21 (.858)
Venture Capital Array Funding (t)	.106*** (.033)
Population Age at Entry (u_0)	.181 (.145)
Percentage of Firms in RAB (t)	13.2 (7.80)
Density of Products (t)	-.048*** (.013)
Density of Firms Outside Bay Area (t)	.278*** (.079)
Density of Bay Area Firms (t)	-1.76*** (.410)
Density of Bay Area Firms (t) Squared	.038*** (.008)
N of Observations/Spells	1539
N of Firms	258
N of Exit Events (does not include Acquisitions)	114
Log Likelihood	-201.9
Chi Square vs. null (constant rate)	168.2
D.F.	23

*** $p < .01$; ** $p < .025$; * $p < .05$. Note: Exit event does not include acquisitions.

Notes

[1] Valuation is used here with respect to expectations about the form, not its social or economic value per se. To distinguish the ideas, Pólos et al. (1999; 2002) refer to their concept as κ-valuation.

[2] However, it would not be impossible for a large firm to embody several forms at once, including some that are "oppositional" in nature. Zuckerman and Kim (2003), for instance, note that some film companies manager to operate simultaneously in the mass and art markets with separate organizational subunits, each with distinct form identities (e.g., Fox and Fox Spotlight) and without apparent penalty. Our point is simply that the presence of such organizations does not facilitate—and might impede--the emergence of a new form.

[3] As Pólos et al. (1998) explain, the organizational form concept plays three major roles in sociological theory and research (see also Carroll and Hannan, 2000). First, researchers use notions of form to define populations of organizations for study. Second, form refers to a selection-favored conglomerate of properties, often embodied in a structural architecture. Third, the form concept seeks to differentiate between core and peripheral features.

[4] This wide range of usage can be seen clearly in a recent (1999) focused issue of Organization Science on new organizational forms. We could not find a definition of the form term by the editors, but the various articles used form to mean: population, industry, M-Form, functional form, divisional form, matrix form, virtual corporation, boundary-less organization, hollow corporation, dynamic network form, cellular organization, hypertext organization, platform organization, and shamrock organization.

[5] Institutional theorists emphasize how formal institutions, such as industry associations, professional associations, and regulatory bodies, assist in the establishment of a new organizational form (Scott 1995). Theorists view these institutions as providing social order and reducing uncertainty, as well as control or domination. Indeed, in the disk array market McKendrick and Carroll (2001) identify two

large and important formal associations of producers. Much as institutional theory would predict, these associations concern themselves with problems of order, especially standardization. By the time of their establishment and full-scale operation, however, these institutions did not serve to spawn and organizational form among producers. Statistical analyses provided below show the effect these bodies may have on the early legitimation building process.

[6] McKendrick and Carroll's (2001) empirical exercise is casual, to be sure. A better systematic test would involve relating density levels to changes in population vital rates reflecting a process of legitimation. We report such tests here but quickly move on to tests of a more developed theoretical story about perceptually focused identities because it appears McKendrick and Carroll (2001) are right.

[7] Of course, there is an extensive prior literature about the effects of *de novo/de alio* status on firm mortality and failure rates (see Carroll et al. 1996 for a partial review). A general finding of this literature is that *de alio* firms experience lower mortality rates, especially in early years. This suggests too that *de alio* firms are stronger competitors. Nonetheless, it is important to recognize that the theory developed here concerns the effects of densities of *de novo/de alio* organizations on a focal organization, not about the *de novo/de alio* status of the focal firm, which is the subject of almost all prior research. So, the prior literature on *de novo/de alio* entry is only suggestive at best. Moreover, we know of no other published research using densities of *de novo/de alio* firms in the ways we do here.

[8] For example, according to Disk/Trend, in 1992, all non-major U.S. captive producers collectively represented $46.7 million revenue. Since there were 15 non-major U.S. captive producers that year, we assigned each one of these smaller array producers a firm-specific revenue of $3.1 million that year. For firms that existed prior to 1992 (and Disk/Trend’s collection efforts here), we again linearly interpolated backwards revenues for these earlier annual spells, using their revenue trajectory from 1992 to 1998 as the functional form.

[9] We also examined a more narrowly constructed density count of firms located in Silicon Valley that excludes the handful of firms in the Bay Area often considered just outside of Silicon Valley, including Burlingame and Fremont. Exploratory analyses revealed virtually identical results for either of these different geographically-based density specifications, and thus we report the more inclusive one.

[10] A currently popular way to incorporate spatial concerns in models of agglomeration uses the actual geographic distances of organizations from each other, sometimes as weighted density variables (see Sorenson and Audia, 2000; Sorenson and Stuart, 2001). When theoretical ideas concern the costs or frictions of spatial distance, these measures are superior to simple counts of density within specified geographic areas because they contain more detailed information. However, the theoretical ideas here concern the interaction patterns occurring within places with related identities themselves; organizations either reside in such places or they do not, meaning the relevant theoretical distinction is categorical in nature. Hence, we use densities grouped by geographic area in examining the possible effects of agglomeration in such places.

[11] As Tables 1 and 2 show, the same covariate may have different minimum and maximum values in the models used to estimate entry as compared to exit. There are two reasons for this. First, for time-varying covariates, we use one-year lagged values of these covariates in the entry models, consistent with the standard procedure for estimating rates of entry (see Carroll and Hannan, 2000), and use non-lagged values for the exit models, where the lagging is not necessary and is not appropriate in our industrial context. Second, as described earlier, the entry models are based on quarterly counts, while the exit models are based on yearly counts (since most covariates in the exit models are based on yearly observations). For example, in 1993, in the exit models, there were two *de novo* array producers in the Boston Area (Cambridge Technology and Invincible Technology). However, because these two producers never existed in the same quarter--Cambridge exited in the first quarter of 1993 and Invincible entered in the second quarter of 1993--the entry models reveal a maximum of

one Boston *de novo* producer over our (quarterly) observation period.

[12] As Tables B1 and B2 show, some variables are highly correlated, especially for the founding/entry dataset. For many covariates, high correlation is not a practical problem because these variables are not included in the same statistical model. In other cases, such as industry revenue and all array density, or *de novo* and *de alio* density counts, there are important theoretical and methodological reasons for wanting to include highly correlated covariates in the same model. These latter cases suggest potential problems of estimation based on "multicollinearity" (see Maddala, 1988; Kennedy, 1992; Greene, 2000).

Multicollinearity can lead to two main problems of statistical estimation: (1) elevated standard errors and (2) estimates sensitive to the inclusion or exclusion of observations in a sample (see Maddala, 1988: 223-227; Kennedy, 1992: 176-187; Greene, 2000: 255-257). In terms of the first issue, estimates with collinear data do not violate the standard assumptions of regression and offer unbiased and efficient estimates (Kennedy, 1992: 177-178; Greene, 2000: 255-256). In this regard, multicollinearity is an issue of not having enough information or variance in the data, irrespective of whether this is due to high correlation among independent variables, inadequate variability in the data, or simply small sample size (Kennedy, 1992: 179-180, 183). For these reasons, if one finds statistically significant support for covariates with collinear data, most econometrics textbooks suggest that multicollinearity is usually not a problem for estimation. For example, Goldberger (1989: 141) believes multicollinearity should be called "micronumerosity," the problem of having a small sample size. Maddala (1988: 229) points out that most tests to detect multicollinearity, including the variance-inflation factor and condition number, are "only measures of how bad things are relative to some ideal situation, but the standard errors and t-ratios will tell a better story of how bad things are." Kennedy (1992: 181) mentions the following rule of thumb about multicollinearity: "'Don't worry about multicollinearity if the t statistics are all greater than 2.'"

If data show signs of multicollinearity, however, estimates can be highly sensitive to the inclusion or dropping of observations in a sample (Maddala, 1988: 225; Kennedy, 1992: 183; Greene, 2000: 256-257). For example, Greene (2000: 257) shows how the exclusion of one annual observation in a collinear dataset radically alters parameter estimates. Fortunately, this potential problem can be checked by adding or dropping observations and examining the sensitivity of parameter estimates to these changes (Maddala, 1988: 225).

Since the effects of many of our key explanatory variables show statistical significance (at the level of $p < .05$), we are fairly confident that with our specifications issues of multicollinearity do not affect the findings. However, to be on the safe side, we re-ran our entry models, which would be most susceptible to multicollinearity, without the last quarterly observation to determine the sensitivity of our estimates. As we report in Appendix tables C1 and C2, the estimates are generally not sensitive to this change in the data. In most cases, estimates are altered only at the third decimal (to the right of zero), if at all. When estimates are affected more than that (at a change in the second decimal to the right of zero), the change amplifies the hypothesized effects both in terms of the size of the coefficient and the statistical significance of the estimate. This again suggests that these analyses are not greatly affected by multicollinearity.

[13] Given the limited number of observations in entry dataset (51 quarters) and potential problems of multicollinearity, we do not want to "over-specify" the models by simultaneously including all of the control and predictor variables, especially those based on similar measures, such as all product density and OEM/PCM product density, as well as the covariates based on the same organizational density counts (e.g., all array density and *de novo* density). As we discussed, such an approach would sometimes generate estimates with many non-significant effects even though sparser models with the same variables show highly significant effects. So, we do not estimate a single model with every control and predictor variables; instead, we follow standard practice and rely on models that include reasonably good-fitting specifications of relevant variables. A similar logic also applies to

our modeling of disk array exit models, where correlations among some variables might cause problems of multicollinearity.

[14] In the models reported here, we focus on the linear specification of organizational density, consistent with our theorizing. However, in a minority of the models, a quadratic specification of organizational density improves the statistical fit of the model. In these cases, we note this in the text and include the quadratic specification in appendix Tables D1 and D2. For example, for Model 1, the quadratic of all array producer density improves model fit and is reported in the Appendix. In all of these cases, the coefficient of the linear term has the same direction in both specifications (e.g., the linear term of all array producer density significantly increases entry under both specifications). Moreover, based on exploratory analyses of the substantive effects of organizational density on entry and exit rates, none of the quadratic terms ever has a substantive effect that overwhelmed the linear term's effect.

[15] In exploratory analyses, we also examined two alternative measures of the density of OEM/PCM products: the more inclusive category of products that serve the OEM/PCM market but also can be used in the captive market and the products of OEM/PCM firms even though their products may also be used in the captive market. Both of these alternative specifications lead to the same non-significant positive effect on firm entry.

[16] In Models 6 through 8, the density of firms outside the geographic agglomerations of Boston, California, and the Bay Area reduce entry rates (in one case, non-California firms, this is statistically significant). If firms outside of Boston are primarily in California and the Bay Area, and firms outside of California and the Bay Area are primarily in Boston, this would seem to be a puzzling finding since Boston, California, and the Bay Area are all associated with increased entry rates. In fact, the geographic distribution of array producers is rather dispersed across the United States and the world. 59% of all non-Boston array producers are outside of California, while over 88% of all non-California and Bay Area firms are outside of Boston. (These percentages are the same if we use

firm-year spells instead of number of array producers.) Disk array production occurs in 24 different states and 12 different foreign countries. For these reasons, we view this effect as consistent with our theorizing about geographic agglomerations.

[17] As with the earlier models of geographic agglomeration, we continue to find that firms outside of the geographic agglomerations of Boston, California, and the Bay Area reduce firm entry (Models 9-11). As we noted before, we view these findings as consistent with our theorizing about geographic agglomerations because disk array production is geographically dispersed, notwithstanding important concentrations in Boston, California, and the Bay Area.

[18] Estimates of array producer exit do not hinge on the distinction between array producer mortality due to disbanding/exit to another industry versus merger/acquisition. Rather, the findings substantively hold with either definition of producer mortality.

[19] In exploratory models, we also used annual sales of personal computers over our observation period in lieu of worldwide array revenue with very similar non-significant positive effects on array exit.

[20] Simpler specifications introducing fewer control variables at a time yield similar findings.

[21] See Appendix D2 for the quadratic specification of this model. It is worth noting that models that include the quadratic of Bay Area density offer results supporting Hypothesis 2b. In these models, firms outside of California significantly increase firm exit, while Bay Area firms significantly reduce exit at low density but increase exit at high density. However, the substantive effects of the linear specification, which reduces exit, are never overwhelmed by the positive effects of the quadratic term.

[22] On a related note, we find that the density of firms outside of Boston, California, and the Bay Area increase rates of exit (significantly for non-Boston and non-Bay Area firms). This is similar to our earlier findings that these densities reduce firm entry. Although we do not specifically theorize about either of these effects, we believe it is generally consistent with our theorizing about the role of

geographic agglomeration in facilitating organizational form development. That is, outside of important concentrations in Boston, California, and the Bay Area, disk array production is generally geographically dispersed, and this geographic dispersion should hinder organizational form development.

[23] As we earlier noted in regard to the effects of Boston *de alio* density in increasing array producer entry rates, Boston *de alios* may also reduce exit rates given their disproportionate role in geographic agglomeration (Model 21), since Boston area density significantly reduces exit rates (Model 18). We are a little more puzzled about why California and Bay Area *de alio* firms would significantly reduce exit rates (Models 22 and 23). *De alio* firms do not have the same disproportionate role in geographic agglomeration in California and the Bay Area and we do not find significant effects of California and Bay Area geographic agglomeration in reducing exit rates (Models 19 and 20). There may simply be more complex competitive dynamics involving California and Bay Area firms than our present theorizing and modeling, as well as the scope of this paper, can capture.