Dynamics of Niche Width and Resource Partitioning[1]

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This article examines the effects of crowding in a market center on rates of change in organizational niche width and on organizational mortality. It proposes that, although firms with wide niches benefit from risk spreading and economies of scale, they are simultaneously exposed to intense competition. An analysis of organizational dynamics in automobile manufacturing firms in France, Germany, and Great Britain shows that competitive pressure not only increases the hazard of disbanding but also prompts organizational transformations that give rise to processes of resource partitioning. Emphasizing the content/process distinction in conceptualizing organizational change, the article finds that the process effect of changes in niche width and position increases mortality hazards. We discuss our findings in light of the processes investigated by the ecological theories of density dependence, resource partitioning, and structural inertia, and point to the theoretical links that help to integrate these theories.

INTRODUCTION

This article investigates processes at the intersection of density-dependent evolution and resource partitioning. In particular, it examines the effects

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of crowding in the center of a market on rates of change in organizational niche width and on organizational mortality.

Consider a product market defined in terms of a single dimension—engine capacity of automobiles in our empirical application. Producers locate themselves in such a market by choosing an array of products. Specialists offer products with a small range of variation on the dimension of interest, and generalists display a broad range of products. In addition to choosing a range (niche width), each producer also chooses a location, which we identify as the center of its product range. Specialists have great freedom in choice of location; they can locate in the center or toward either periphery (above and below the center). Generalists face more constraint in choice of location because a wide niche covers much of the market; yet, they can still choose whether to locate the center of their range near the center of the market or toward one of the peripheries.

The emergence of a center in a market with many producers means that consumer preferences have become concentrated on a relatively narrow range. The concentration of consumers at a center has two consequences. First, producers who gain leadership in the center can grow very large, and often they can exploit economies of scale. Second, the attractiveness of the center intensifies competition in the center (at least initially), as many producers seek to match their products with consumer preferences.

How does crowding in the center affect the organizations in a market? According to density-dependence theory (and, especially, its generalizations to localized-density models), crowding intensifies competition, which, in turn, elevates mortality hazards. This theory posits that crowding increases the mortality hazards of organizations located in the center. Such an effect should be especially pronounced for specialists located in the center, who have nowhere to hide. In contrast, generalists whose niches span the center can potentially offset some of the deleterious effects of crowding in the center with success in less competitive regions covered by their wide niches.

Technological niches, though subject to strong inertial pressures, are not fixed. Crowding arguably induces organizations in the center to try to modify their niches. Obviously, this can mean change in niche width or change in niche position. So, for instance, specialists in the center might stay specialized but may move to a peripheral position or broaden their niches without changing the centers of their niches.

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If change in a technological niche requires fundamental reorganization, then such change increases the risk of mortality, at least in the short run. So, crowding has a possible indirect effect on organizational mortality by stimulating changes that heighten the risk of mortality.

Because the effects of crowding on mortality and the risks due to changes stimulated by crowding depend upon an organization's position and niche width, the processes involved arguably can give rise to market partitioning. For instance, resource-partitioning theory (Carroll 1985; Carroll and Swaminathan 2000; Dobrev 2000) assumes that, if generalists are present in the center, then specialists can thrive only in the peripheries. This is an obvious potential consequence of the microprocesses described above. However, these processes can produce other patterns as well.[2]

We examine these issues in the context of the automobile industries of France, Germany, and Great Britain. The automobile industry has a major advantage for study of the dynamics of crowding and resource partitioning: specialism and small size can be clearly distinguished. This matters because some recent research on partitioning processes treats specialization as equivalent to small size (Boone, Bröcheler, and Carroll 2000). Although specialists tend to be small in some industries, there is no inherent connection between size and specialism. Given the current state of empirical knowledge, it is important to distinguish the effects of size from those of specialism, as our empirical setting allows. In the automobile industry, some specialists have grown very large. Indeed, no firm has so thoroughly dominated the world automobile industry as Ford in its heyday in which it offered a single model, the Model T.[3] Examples of dominant firms with very narrow niches in European automobile industries include the Great Horseless Carriage Company in the 1890s, Adam Opel in the 1920s, Volkswagen in the 1950s and 1960s, and Renault in the 1960s.

NICHE WIDTH, POSITION, AND LIFE CHANCES

A fundamental sociological insight holds that opportunities and constraints are inextricably linked to actors' locations in a social structure. The concept of organizational niche builds on this view. A niche summarizes the ways in which social action (collective and individual) hinges

[2] It is worth noting that the possibility that small niches suitable for specialists can persist in the center as a consequence of the geometry of sphere packing (Péli and Nooteboom 1999) does not apply to the case we consider. The niches we consider are one dimensional; the densest packing is complete in this case.

[3] Various versions of the Model T, with only one engine offered at any one time, garnered sales of over 15 million cars during 1908–27. For some of this period, Ford controlled over half of the world market for automobiles.

on the position of focal actors in a social space.[4] Our focus on organizational niches stems from our desire to understand how an organization's position in an industry shapes its life chances. An analysis of niches allows us to understand the behavior of organizations as it reflects the competitive and symbiotic dynamics of interaction within a particular market segment.

Niche width refers to an entity's variance in resource utilization (Hannan and Freeman 1989). This representation proves useful for classifying organizations in terms of generalist (wide niche) and specialist (narrow niche) competitive strategies. Claimed benefits of specialism (or generalism) for organizational performance have received much attention. Conventional strategic analysis builds on an especially simple notion—for firms to grow, expand, and increase profitability, they must diversify (Chandler 1962; Steiner 1964). Entry into new markets, products, or services not only allows the firm to tap potentially unexplored resources, but also reduces risk by spreading it over several operational domains. Additionally, diversification generates economies of scale and scope across similar functions in the separate lines of business (Paine and Anderson 1983). Thus, generalism is not merely a desirable state; it stands as a requisite for successful organizational performance on this view.

The purported advantages of a generalist strategy underestimate the importance of the timing in the industry evolution, fluctuation in resource flows, market concentration, and distributions of organizational size and age. Environmental processes have been emphasized in the work on organizational niche theory (Freeman and Hannan 1983; Hannan and Freeman 1989; Péli 1997). This theory specifies the configuration of environmental conditions under which the generalist strategy conveys advantage. In particular, the theory posits that generalists are favored when environmental variation is high and the pattern of variation is coarse. Our reading of the history of the industry suggests that changes in technology and in consumer tastes have been highly uncertain over the history of the industry and that changes have occurred irregularly over time. In other words, we think that variations in key environments of this industry have been highly uncertain and coarse grained. Our hypothesis about the main effect of niche width on mortality hazards is based upon this assumption. That is, in the case of automobile manufacturers we argue:

HYPOTHESIS 1.—*An organization's hazard of mortality is a decreasing function of its niche width.*

[4] Although the constructs of organizational niche and niche-overlap density are closely associated with organizational ecology (Freeman and Hannan 1983; Hannan and Freeman 1989; Baum and Singh 1994), they have also been used in sociological research on networks (Burt 1993), work that combines network and ecological themes (McPherson 1983; McPherson, Popielarz, and Drobnič 1992; Podolny, Stuart, and Hannan 1996), and research on social movements (Olzak and Uhrig 1999).

Above we noted the strong connection between an entity's niche width and the degree to which its niche overlaps the niches of others. When an organization broadens its niche, it cannot decrease overlaps and generally increases them. So a complete analysis of the consequences of niche width must take account of the excess overlap entailed by broad-niche strategies.

Our argument about the pattern of competitive intensity triggered by niche crowding builds on ideas about localized competition (Hannan and Freeman 1977; Barnett and Carroll 1987; Podolny, Stuart, and Hannan 1996; Han 1998) and the theory of density-dependent legitimation and competition (Hannan and Carroll 1992, 2000). We argue that the intensity of competition experienced by an organization in a market segment is a positive increasing function of the number of niches it overlaps, that is, its niche-overlap density.[5]

HYPOTHESIS 2.—*An organization's mortality hazard is a positive increasing function of its niche-overlap density.*

Niche theory, like other first-generation theory fragments in organizational ecology, deals with highly general specifications. In particular, it assumes that the conditions that favor generalism or specialism hold universally (Carroll 1984). In the years since niche theory was developed, we have learned about diverse forms of population and industry structure that develop over time, as identities and positions become defined and solidified. Hannan (1997) makes use of these arguments to argue that the effects of density on competition (and legitimation) are intense at the early stages of population growth when populations and industries lack structure and that they decrease in strength over time. As an industry consolidates in form and content, the patterns of organizational interaction gradually become embedded in the evolving industry structure. Possibly, in certain cases, the increase in niche-overlap density might represent the type of syndicate and alliance formation among newly established partners, rather than the clustering of potential competitors. Analyses of resource partitioning have also shown that relationships among specialist entrants tend to form on the basis of symbiotic cooperation instead of

[5] Not all work on competitive intensity would agree with this proposition. For instance, some industrial economists have argued that the transition from monopoly to duopoly has crucial consequences for strategy formation. Bresnahan and Reiss (1991) show that, for markets with three to five competitors in localized markets, the addition of any additional competitors does not make a substantial difference. Ecologists Barnett and Hansen (1996) show that, among Illinois banks outside of Chicago, only the arrival of the first competitor in the town increases the focal firm's chances of failure significantly. Their results suggest that "additional increases in the number of competitors in a local market actually decrease failure rates" (1996, p. 153). We explored this issue by supplementing the usual parametric analyses of the effects of overlap density with a more flexible specification. As we describe below, we found that the effect of overlap density is much stronger at higher densities.

cutthroat competition. In the case of the U.S. brewing industry, for example, the wave of entries of small niche producers (microbrews and brewpubs) strongly resembles the coevolving mutualism typical of a social movement (Swaminathan and Carroll 1995, p. 236). In general, the deleterious effect of niche crowding on survival chances ought to fade as an industry matures (Hannan 1997).

HYPOTHESIS 3.—*The effect of niche-overlap density on an organization's hazard of mortality declines with industry age.*

INERTIA, CHANGE, AND LIFE CHANCES

It is important to recognize that the predicted effects of niche width and niche-overlap density do not fully reveal or account for the experiences of all—or even most—organizations in competitive markets. For example, rarely does a firm enter the market with a certain set of product offerings and manage to sustain that exact same set throughout a long tenure in an industry. Whether as a result of innovation, copying from successful competitors, or obsolescence, product turnover is an inevitable part of keeping in pace with industry development. As new products become introduced and old ones abandoned, as mandates for technological comparability and standardization intercede with financial objectives and limited resource availability, the line of product offerings that each firm can bring to market might vary substantially. So for many reasons—strategic, institutional, or random—the boundaries of an organization's niche and its width likely will fluctuate. We believe that such transitions involving change in niche width and market position have vital consequences for the organizations that initiate them. Thus understanding the likely advantages and disadvantages conveyed by niche width and market position requires that we also investigate the processes by which organizations acquire such characteristics. We turn to this issue next by bringing in insights from several ecological theories, including structural inertia, resource partitioning, and organizational learning.

Do efforts to broaden or narrow the array of an organization's technological competencies, or attempts to reposition in the market in search of new opportunities or of a less competitive sector, affect organizational performance and survival chances? Adaptation and selection theories supply different arguments to answer the question. The former frequently point to the benefits that an organization can derive once the desired transformation has been completed, whereas the latter emphasize the difficulties associated with accomplishing the transition. Thus, the main issue in the lingering debate between the two perspectives has centered on whether the costs of implementing organizational change outweigh the potential benefits of its outcome, or vice versa.

A body of recent empirical research has singled out several important factors that—when taken into account—help to reconcile the adaptation and the selection arguments. This research shows that changes in core features of the organization increase mortality hazards, while changes in peripheral attributes sometimes have the opposite effect. Hannan and Freeman's (1984) structural-inertia theory, which posits that core change degrades structural reproducibility and hence lowers an organization's ability to act as a reliable and accountable collective entity, has been confirmed in most empirical studies conducted using the appropriate research design (Barnett and Carroll 1995; Carroll and Hannan 2000). Examples of studies showing that mortality hazards rise with core change include research on several newspaper populations (Carroll 1984; Miner, Amburgey, and Stearns 1990; Amburgey, Kelly, and Barnett 1993; Dobrev 1999), telephone companies (Barnett 1994), voluntary social service associations (Singh, House, and Tucker 1986), social movement organizations (Minkoff 1999), banks (Han 1998), and film-production companies (Kim 1998, 2000).

Barnett and Carroll (1995) criticize research on this subject for failing to distinguish between the content and the process of change. They argue that research is most informative about the hazards of change when it separates the effect of the characteristics of the state to which an organization is moving from the various obstacles and impediments it undergoes in trying to get to that state. Understanding why organizations fail to achieve the desired outcome of internal transformation or why they simply fail, involves understanding the process dimension of change.

We define two types of organizational-level transformations, each pertaining to position in the market. Then we decouple the content from the process dimension in each. We begin with change in organizational niche. Hypotheses 1 and 2 posit that organizations with wide product niches will benefit from taking advantage of economies of scale, more adaptive resource utilization, and risk spreading, but, at the same time, will face stronger competitive pressures. These hypotheses concern states, not processes at the organization level. Therefore, from the perspective of an organization's changing its niche, these hypotheses relate solely to the content of change. Yet, implementing a substantial change in niche width likely triggers additional unintended effects associated with change, per se. The theory of structural inertia predicts that the process effects will have deleterious consequences for survival chances if such changes entail fundamental organizational transformation.

Why should this be so? The explanations concern both the organization and population levels. The loss of established routines and practices means losing capabilities and competencies that need to be replaced with new ones that take time to develop. The likely reshuffling of the political status quo and the internal balance of power generates individual resilience and inertia as well as fear of the unknown (Dobrev and Barnett 2001). Relationships that rest on trust are slow to rebuild. Fundamental change also disrupts the intra- and interorganizational networks among employees as well as between the organization and its external constituents that act as depositories of organization-specific tacit knowledge. In short, the process of organizational change resets the liability of newness clock (Hannan and Freeman 1984; Amburgey et al. 1993; Péli, Pólos, and Hannan 2000).

To develop and test these arguments, we need to define market position, change in market position, and the difference between the content and process of change. One useful way to conceptualize the social structure of a market follows the resource-partitioning model. It construes the market as a reflection of an intersection of dimensions capturing the distributions of industry-relevant consumer preferences. The peaks of those distributions tell us where the market center lies—where resources are most abundant and competition is ordinarily stiffest. Market position of an organization then can be defined in terms of its distance from the market center, and change in market position corresponds to the difference in that distance between sequential observations. The content of change in this context refers to the costs and benefits associated with the position to which the organization is aspiring to move (as contrasted with those for the state it is leaving).

By contrast, the process dimension reveals the difficulties of actually implementing and undergoing such a transition. The market and its center, of course, are dynamic constructs that can also change continuously. Although an organization can experience a change in its relative position without making any changes in its own product offerings, the argument linking the process of organizational change to increased exposure to selection pressures and higher likelihood of disbanding would not apply to such cases. Integrating the theory of structural inertia with the conceptual differentiation between content and process change yields the following two hypotheses predicting negative effects of process change in niche width and in absolute market position on survival chances of automobile manufacturers.

HYPOTHESIS 4.—*Change in an organization's niche width increases its hazard of mortality.*

HYPOTHESIS 5.—*Change in an organization's absolute market position increases its hazard of mortality.*

Crowding, Learning, and Rates of Change in Organizational Niches

Another important issue in studying organizational change concerns the ability to discern direct and indirect effects that might impact the outcome of internal transformation. For example, in their research on Finnish newspapers, Amburgey et al. (1993) find that organizational age has pronounced effects on the rate of disbanding and on the rate of change. The findings suggest that young organizations are more likely to change and less likely to experience the negative repercussions of that change. Understanding the possible compounded effect of certain organizational attributes on internal transformation mandates analyzing their relevance for survival chances and also the degree to which such factors influence the propensity to implement change.

Above we argued that niche-overlap density would increase mortality risks by stiffening competition. Yet, not all organizations fail as a result of intensified market-segment rivalries and depleting resources. What alternative strategy might such organizations pursue? To answer this question, we turn to the resource-partitioning theory (Carroll 1985). This model derives market segmentation as a result of strong competition for position in the most lucrative sector of the market. The process drives industry concentration high, as typically just a few generalists end up occupying the market center. The rest of the competitors either fail or retreat toward the periphery where they tend to specialize and explore untapped resources. We think the transition toward the market periphery entails significant reorganization. Whether aimed at meeting the demands of new consumer groups or at expanding emergent specialized market segments and creating demand by introducing novelty products, the move from a more to a less saturated market segment likely involves both change in market position and in niche width. So, based on the resource-partitioning process, we expect that heightened competitive intensity not only increases mortality hazards, but it also promotes the occurrence of internal change.

HYPOTHESIS 6.—*An organization's likelihood of changing its niche width and position increases with its niche-overlap density.*

The management literature generally emphasizes the value of organization's capacities to learn (Argyris 1999). Much of the sociological literature underscores the hazards and limitations of organizational learning (March 1991; Hannan and Freeman 1989). The two perspectives, however, are not contradictory. Organizations do indeed learn from what they do and eventually become better at it. Their propensity to do what they have learned and have become good at increases concurrently. This organizational feature, of course, need not be construed negatively as long as the substance of the cognitive accumulation itself constitutes the right course of action under the prevailing environmental conditions. However, the dynamic and multifaceted nature of the environment and the changing needs of the organization at each stage of its life cycle demand continuous realignment between an organization's strategy and its external constituents. In that context, falling in a competency trap (March 1988) by relying more on and becoming better at an infeasible course of action is a doomed strategy that results from the mixture of past learning and inertia. We examine possible path dependence in change processes by testing the following hypothesis.

HYPOTHESIS 7.—*The greater an organization's experience with a type of change, the greater is its likelihood of repeating the same type of change and the lower is its likelihood of making other kinds of changes.*

Organizational sociologists have pointed to a link between structural complexity and inertia (Hannan and Freeman 1984; Barnett and Carroll 1995). If organizations with complex structures are inherently less capable of fundamental change, what do they learn from their experiences? Assume that the capacity to learn and the type of change incurred are held constant for all organizations (regardless of the complexity of their structures). Just as we expect organizations with simpler designs to learn how to change and to repeat the same changes that they have already survived, this should be less true for complex organizations. In other words, we think that the "momentum of change" declines with complexity. We do not have a direct measure of organizational complexity. However, our reading of the primary sources on this industry leads us to think that organizational complexity for automobile manufacturers tends to be directly proportionate to their niche width. Based on this assumption, we conjecture that

HYPOTHESIS 8.—*The effect of an organization's experience with a type of change on its likelihood of repeating that change declines with the complexity of the organization.*

Completing the Model

We agree with Barnett and Carroll (1995) that modeling internal organizational change will not be complete unless the general evolutionary trends of the industry are taken into account. So we try to account for all of the relevant factors that earlier research on organizational change and ecological research on determinants of rates of organizational disbanding have indicated to be relevant.

Previous research shows that organizational age and size have a profound impact on both organizational mortality and rates of organizational change. We introduce a measure of relative size, which makes it possible to interpret the effects of size in relation to a reference category, namely, the largest organization by year in the population. We use Hannan et al.'s

(1998*a*) nonproportionate specification, which allows the effects of age and relative size to interact in affecting mortality hazards.

We include a dynamic specification of the density-dependence model where the density terms are interacted with population age to capture the different cycles in the history of the industry (Hannan 1997; Hannan et al. 1998*b*; Dobrev 2001). Following Hannan et al. (1995), we also distinguish between the effects of system-level (European) and subsystem-level (country-specific) density to reveal the multilevel nature of the density-dependence process. It posits that legitimation can diffuse the image and identity of an organizational form across national boundaries and operates at a broader level than competition, which is constrained geographically within national markets.

Organizational age has also played an important role as an explanatory covariate in previous analyses focused on the effects of change on survival and determinants of rates of organizational change. For example, Amburgey et al.'s (1993) study of Finnish newspaper mortality found that only old newspapers faced increased hazards when they attempted core change. They also show evidence that the occurrence of organizational change gets modified by organizational age in two important ways. First, the rate of change decreases with organizational age, and second, the momentum effect of prior change is more pronounced for younger organizations for one type of change, but stronger for older organizations for another. By contrast, a study of core change and survival of social movement organizations in the United States reports that older organizations are more likely to change, while the momentum of change declines with age (Minkoff 1999).

RESEARCH DESIGN

This research uses data on the automobile industries in France, Germany, and Great Britain. It considers the full history of the automobile industry, starting with 1885 and ending with 1981, the last year of full coverage in our most comprehensive source of data. The data come from a study that coded histories of automobile manufacturers worldwide from reports of automobile historians and collectors.[6] The most comprehensive information comes from two encyclopedias: Georgano (1982) and Baldwin et al. (1987). Because the sources highlight automobiles as technical products, the resulting histories of firms pertain to spells of automobile production not to lifetimes of the firms. These sources organize their reports around *marques*, not firms. Entries for *marques* had to be combined to create

[6] Hannan et al. (1995) and Carroll and Hannan (2000) provide details on the design.

records for firms. The records contain information about spells of automobile production by firms but not about their complete lifetimes, which sometimes involved operation in another industry before or after a spell of automobile production. In some cases, the sources do tell about the creation and destruction of the firms. Insofar as the sources permit, the research team reconstructed the organizational histories of the firms in these industries.

This coding effort yielded data on 828 French, 373 German, and 995 British firms. Many were small, short-lived, and obscure and left little historical record. However, including information on such obscure organizations is crucial to sound inference about the causes of organizational mortality. Keeping short-lived firms in the analysis means relying on incomplete information. Therefore, we made several assumptions about obscure, short-lived firms to allow us to include them in the analysis, as we explain below.

Entry and Exit Events

Organizations entered automobile production by several paths, as we noted above. Three were especially common: (1) a firm is built *de novo*—it has no prior organizational experience at time of entry, (2) a new firm results from a merger of automakers or by the division of one automobile manufacturer into two or more firms, or (3) a firm enters from another industry. For the obscure firms, we know only that they began automobile production but not whether they migrated from other industries.[7] This set presumably includes both newly founded firms and entrants from other industries. The more complete American data indicate that both types of entry were very common.

Previous research on these populations found that the life chances of lateral entrants and firms that arise by merger or fission of automakers were better than those of firms that began de novo or whose type of entry is unknown. However, using the distinction between lateral entry and start by merger or fission did not improve model fits significantly. Therefore, as in previous research, we use only one distinction about type of entry in this analysis: whether a firm has *prior existence* of any kind (either in the automobile industry or in some other industry). We treat firms with unknown entry events as not having existed previously.

For ending events, the most important distinctions concern (1) dis-

[7] Individual entrepreneurs surely did come from other industries, and this information is sometimes available. However, our unit of observation is the organization, not the entrepreneur. For us, the key distinction is whether the organization is new at automobile manufacturing.

banding, (2) exit to another industry, and (3) merger or acquisition. Disbanding has an unambiguous meaning: the firm failed as a collective actor. Exit to another industry also suggests a lack of success in automobile manufacturing. Although merger and acquisition both result in the loss of one or more independent collective actors, firms merge and acquire 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. Because of the ambiguous meaning of mergers and acquisitions, we concentrate on disbanding and exit to another industry in this analysis (within the limits of the data, discussed next).

We also do not know exactly what happened to most firms when they dropped from the set of producers, especially in the European populations. This is invariably the case when spells of automobile production were short.[8] Apparently, automobile historians rarely could reconstruct the details about an exit unless a firm had become reasonably well established. Knowledge that a certain firm disbanded, was acquired, or left the industry usually means that it persisted in the industry long enough that its exit event received notice in the press.

As Hannan et al. (1998*a*) explain, "unknown exit" could be interpreted as an ending event in its own right, governed by its own transition rate. But, they argue against this idea. Because availability of information on the kind of exit depends (strongly) on tenure in the industry for the European populations, this analytical strategy would confound the specification of the state space (the origin and destination states) and tenure. They note that the historical materials suggest that most exits of unknown type were disbandings or exits to other industries. Analysis of various alternative treatments of the unknown-exit cases lead Hannan et al. (1998*a*) to conclude that events of unknown type were governed by processes more similar to those underlying disbanding and exit. We follow the earlier research in treating 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, nationalization) are treated as (noninformatively) censored on the right at the times of these events.

Dating Entries and Exits

The archival sources contain varying degrees of precision in dating events. Sometimes the sources give the exact date; other times they give only the

[8] This difference shows up clearly when one calculates integrated hazards of the various events as a function of duration (tenure in the industry). The rate of the unknown type of exit is much higher over the early years of tenure (up to about seven years).

month and year or season and year. Most often, they record only the year. To make analysis tractable, all of the information about timing was converted into a common metric; exact dates were represented as decimal years. When dates were given in terms of months or seasons, decimal years were assigned using judgments of the midpoint of the time unit. For example, “early fall” was coded as occurring on October 15 (day 288 in the calendar), giving a decimal year value of 0.79. Dates given to only the year were coded as occurring at the midpoint of the year.

What is normally called organizational age in the literature is, with few exceptions, actually a measure of duration or tenure in a particular organizational population (Carroll and Hannan 2000). Tenures in automobile production can be calculated straightforwardly when dates are exact or nearly exact. The challenging case involves entry and exit in the same year. The data we used impose the assumption that the tenure (in years) in the industry for such a case is bounded by 0 and 1. Such cases are assigned a tenure of 0.5 (the expected tenure under the assumption of a uniform distribution of events over the calendar year). Exits for such cases are coded as occurring at (just before) the end of the year. When a firm enters in one year and leaves in the next (e.g., a firm is reported to have begun production in one calendar year and ended production during the following year), we attach the starting time to the middle of the first year and the ending time to the midpoint of the next year, giving a completed tenure of one year (which is, again, the expected tenure under the assumption of a uniform distribution).[9] These rules generalize to handle all of the relevant cases.

MEASUREMENT

Niche Width

Adapted from the field of bioecology (Hutchinson 1957), organizational niche theory (Freeman and Hannan 1983; Hannan and Freeman 1989) decouples the construct of the fundamental niche—the multidimensional social space in which an organization (or an organizational form) can grow or at least sustain itself—from that of the realized niche, a subset of the fundamental niche in which an organization can sustain itself in the presence of competitors. We follow the lead of Podolny, Stuart, and Hannan’s (1996) research on semiconductor manufacturers, which expresses an organization’s fundamental niche as a function of its position

[9] The general problem concerning data of this kind is known as time aggregation bias. These procedures are consistent with Petersen’s (1991) recommendation for dealing with this problem.

TABLE 1
MEASURES OF NICHE WIDTH, MARKET POSITION, AND CHANGE IN MARKET POSITION

Variable	Definition
$E_{it}^{\max}$	Firm i's largest engine capacity at t
$E_{it}^{\min}$	Firm i's smallest engine capacity at t
$E4_t^{\max}$	The maximum engine capacity among the four largest firms
$E4_t^{\min}$	The minimum engine capacity among the four largest firms
Firm's niche width (W_{it})	$E_{it}^{\max} - E_{it}^{\min}$
Midpoint of a firm's niche (M_{it})	$E_{it}^{\min} + (E_{it}^{\max} - E_{it}^{\min})/2$
Change in niche width ($\Delta W_{it} = 1$)	$W_{it}/W_{i,t-1} \leq 0.9$ or $W_{it}/W_{i,t-1} \geq 1.1$
Expansion	$W_{it}/W_{i,t-1} \geq 1.1$
Contraction	$W_{it}/W_{i,t-1} \leq 0.9$
Width of market center (C_t)	$E4_t^{\max} - E4_t^{\min}$
Midpoint of market center (C_t^{mid})	$E4_t^{\min} + (E4_t^{\max} - E4_t^{\min}) / 2$
Position:	
Distance above market center (P_{it}^a)	$\max(M_{it} - C_t^{\text{mid}}, 0)$
Distance below market center (P_{it}^b)	$\max(C_t^{\text{mid}} - M_{it}, 0)$
Extent of change in relative position (ΔP_{it})	$(M_{it} - C_t) - (M_{i,t-1} - C_{t-1})$
Any change in absolute position ($\Delta P_{it}^a = 1$)	$M_{it} \neq M_{i,t-1}$

in a technological space. Specifically, we measure the niche width of an automobile producer in terms of the spread of engine capacity over all models that a firm produces measured in cubic centimeters (cc) in a given year.[10] (Operational measurements of niche-related measures are presented in table 1.) Firms with a single model or more than one model with the same engine have a minimal niche width, which we set to 1 cc to avoid having to speak of niches of zero width. A firm that produces one or more

[10] When such data were not available but we could find data on horse power, we predicted capacity in units of cc using the coefficients of maximum (minimum) capacity on maximum (minimum) horsepower with controls for historical periods and organizational properties.

TABLE 2
DESCRIPTIVE STATISTICS FOR NICHE WIDTH AND NICHE-OVERLAP DENSITY

	France	Germany	Great Britain
Niche width (in 1,000 cc) minimum:	.001	.001	.001
Max	11.37	20.0	14.3
Mean	1.87	1.85	1.14
SD	2.06	2.24	1.46
Niche-overlap density:			
Min	0	0	0
Max	175	106	218
Mean	70.1	28.0	53.4
SD	49.7	21.8	47.2

models with a very small engine and one or more with a very large engine has a broad niche by this construction.[11]

While the sources frequently provide information on the smallest and the largest engine capacity models, they rarely list all of the models that compose the firm's set of offerings. This precluded us from constructing a measure of number of models produced. However, our study of the data sources leads us to conclude that firms with wide niches that produced very few models (e.g., producing only two models: a single high-engine-capacity model and a single low-engine-capacity model) have been practically nonexistent throughout the history of the industry. In fact, when evidence is available, we find that the most intensely exploited technological space falls at or near the center of the firm's niche. This justifies our assumption that there is little, if any, unobserved heterogeneity related to product range within firms with similar niche width. Table 2 provides descriptive statistics on niche width for the three populations.

Measuring organizational niches along a single dimension—technological scope, in our case—has its limitations. If our measures of niche width and overlap density capture only market position and competitive dynamics in technological space, they would be less than ideal for testing the theoretical propositions stated in the previous section. However, we believe that our decision to define organizational niches along a technology dimension has compensating advantages. Most important, it provides us with a means of making meaningful comparisons of firms that have existed in disparate historical periods, thereby allowing us to analyze the evolution of the industry from its origins. It makes it possible to draw as complete a picture as possible (given the severe paucity of information for many of the entries in our data sets) of the overall market

[11] Arguably, two firms with similar niche widths can differ from one another by the number of models they produce each year.

niches of the automobile firms whose fates we analyze. In other words, we think that technological niches in this industry are informative about market position. We think this is so because, upon examination, the choice of engine capacity made by automobile producers over the years proves to be revealing not only of the ranges of their technological offerings but also of these firms' strategies in product marketing and competitive pricing, customer segment targeting, supply-chain management, and innovation. We illustrate this point below with examples of well-known producers from each of the three European industries we investigate.

In 1922, the renowned British automobile manufacturer Rolls-Royce made a clear change in direction toward expanding its customer base by offering some more affordable models with much smaller engines. In so doing, it also appealed to a customer segment with a different social disposition. The introduction of a smaller-engine model, nicknamed the Baby Rolls, complemented the powerful (big engine) and also very profitable model, known as the Silver Ghost. Interpreting the significance of this strategic decision, the industry historians Baldwin et al. (1987, p. 416) write,

> Although frowned on by the purists, as such innovations always are, [the Baby Rolls] brought Rolls-Royce motoring to a new market, not only those who could not afford a Silver Ghost but those who did not want an enormous car, or those who preferred to drive themselves.

The obvious correspondence between difference in price range and difference in model engine capacity can be seen in the case of the legendary German automaker Mercedes-Benz. In the depression years of the 1930s, the company introduced the smallest Mercedes-Benz ever made until that time, a car with a 1.7 liter engine. Its low starting price of 4,150 marks made it the company's best-selling model of the interwar era; more than 85,000 such cars were sold in less than a decade. At the opposite end of the scale, we find the 7.6 liter engine model, which was

> aptly nicknamed "der Grosser Mercedes." . . . Some of the 177 first series of Grossers were sold to anyone who could afford them (at 38,000 to 47,000 marks), but the 88 second series cars went entirely to the Nazi hierarchy or to foreign rulers such as Joseph Stalin, Finland's Field Marshall von Mannerheim, Spain's General Franco, and Antonio Salazar of Portugal. (Baldwin et al. 1987, p. 122)

The technological range of products offered by an automobile producer also speaks to organizational designs and internal arrangements of the companies, as well as the resources available to them. For example, in the post–World War I period in France, Renault's technological niche ranged from a 9.1 liter engine (in an "elephantine" car), on the high end, to the modest 0.95 liter engine of the Model KJ, on the low end. This extremely broad scope of offerings reflected an expansion of production facilities that allowed the company to make the supply-chain process internal and also clearly provided a resource advantage. According to Baldwin et al. (1987, p. 404),

> As a result of wartime expansion the Renault works . . . in 1919 consisted of 87 built up acres, including a steel foundry, . . . three iron foundries, one aluminum and one brass foundry, general machining shops and assembly shops for all components including bodywork. . . . In 1919 Renault acquired its own steel works . . . the most modern steel plant in Europe.

We think these examples (only a few of the many that we came across during the coding process) justify our reasoning in electing to focus on technological niches of organizations, a choice that allows us to interpret not only the range of product offerings, but also the overall market strategy and position of the firms in our data. That said, we also suspect that the dimensionality of niches in this industry has increased over time, as issues such as safety, durability, fuel economy, and so forth have come into prominence. If this surmise is correct, then our measure of the technical niche does a better job of characterizing firms' complete niches in the earlier portion of the industry history than in more recent times. This reasoning supplies another, slightly different, interpretation of the relationship proposed in hypothesis 3, which states that the effect of (technical) niche-overlap density on mortality rates declines with industry age. By this interpretation, the decline is due to the increasing dimensionality of niches with industry age.

Competitive Intensity

We measure competitive intensity as proportional to niche-overlap density, the number of organizations present in the focal firm's niche. Table 2 provides descriptive statistics on niche-overlap density for the three populations. Notice that the ranges are extremely broad. Each population contains firms whose niches do not intersect any others, and they also contain firms whose niches overlap with hundreds of other firms.

Figures 1–2 show the joint distribution of niche width and overlap density for two time slices, 1900 and 1925, for the French population. (The pattern for the British and German populations is similar.) Notice that only extreme specialists (those whose niches are very close to zero) do not experience high niche overlap. Movement away from pure specialism causes overlaps to increase very sharply.

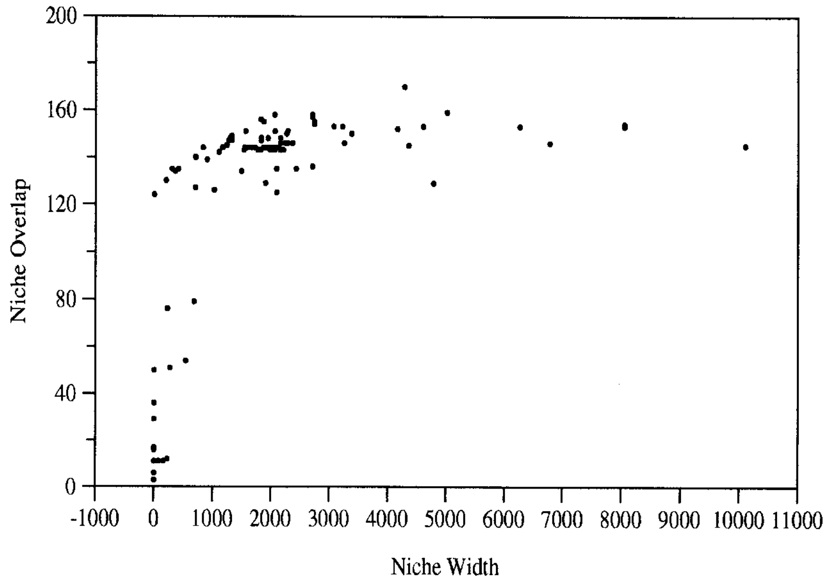

FIG. 1.—Niche width and niche-overlap density in the French population of automobile manufacturers in 1900.

Position Relative to the Market Center

Recall that we want to address resource-partitioning theory's claims about competition in the center of the market. Ideally, we would like to use information on the distribution of consumer tastes to identify the market center. Lacking such information, we use information on the locations of the four largest firms in the (national) market, reasoning that large size can be gained in the market center. We define the range of the center as the range between the lowest minimum and highest maximum engine capacity among the four largest firms and the market center as the midpoint of this range

We measure a firm's position in the market in terms of its distance from this measure of the market center. We distinguish between position on the high end (i.e., producing luxury or sports model cars with high engine capacity) and position on the low end (i.e., producing economy models with low engine capacity). Both measures are set to zero for cases that fall on the other side of the market center from the direction being coded.

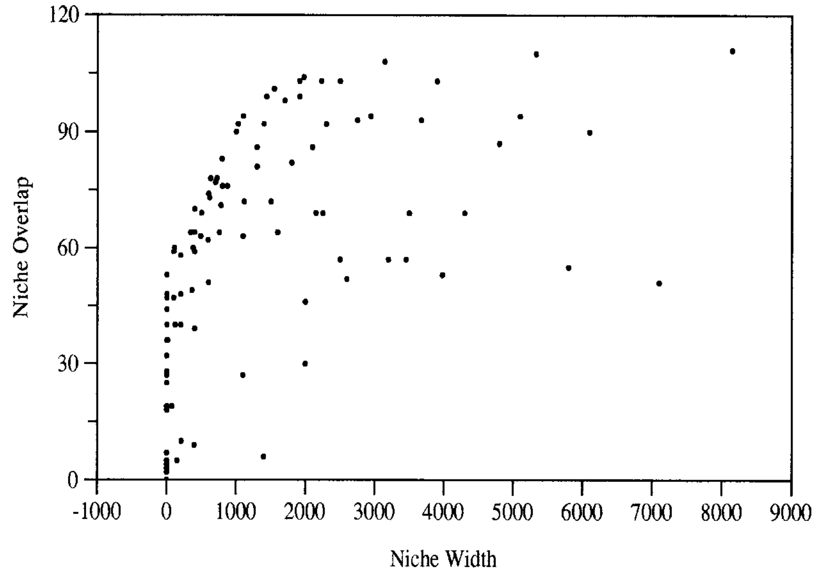

FIG. 2.—Niche width and niche-overlap density in the French population of automobile manufacturers in 1925.

Changes in Niche Width and in Position

Our measures of organizational changes reflect the important substantive dichotomy of content vs. process that underscores our theoretical arguments. We constructed a dummy variable for niche-width change that equals one if the firm's niche expanded or contracted by at least 10% relative to the preceding year. We think an increase or decrease in niche width by at least one-tenth implies a meaningful internal reorganization, sufficient to trigger a change in the organizational core. We agree with Podolny et al. (1996, p. 663) that "an organization might gradually adjust its underlying technological competencies through 'local search,' but significant change in position . . . demands fundamental alteration of the organization itself."

We use two measures of change in position. Relative change in position is the difference in the distance of the firm's niche center from the market center between consecutive years. Because relative change in position might occur without change by the organization (i.e., when only the market dimensions are shifting), we also include a dummy variable for absolute change that captures instances of change undertaken by the organization, regardless of whether such change modifies the firm's position

TABLE 3
FREQUENCY OF CHANGES IN NICHE WIDTH AND POSITION

	France		Germany		Great Britain	
	N	%	*N*	%	*N*	%
Spells with absolute position change	448	8.7	382	16.8	1,478	26.5
Spells with niche width change	602	11.6	273	12.0	1,057	18.9
Spells with both changes	306	5.9	193	8.5	833	14.9
Firms experiencing absolute position change	227	27.7	127	34.0	400	40.5
Firms experiencing niche width change	290	35.4	121	32.4	362	36.7
Firms experiencing both changes	184	22.5	95	25.5	281	29.1

relative to the market center. The frequency of changes in niche width and absolute position are presented in table 3.

Organizational Size: Absolute and Relative

Research on age-varying size and life chances has conceptualized and measured organizational size in two ways: capacity and scale of operations (Barron, West, and Hannan 1994; Carroll and Hannan 2000). We follow the previous research on these populations and concentrate on scale of operations, and we measure it in terms of a firm's *annual production of automobiles.* This measure makes good sense in the context of the industry and its history. Even analyses of the current situation focus on market share, measured in vehicles sold. Moreover, this measure is available more regularly than accounting measures of performance, and it is likely to be measured more reliably in most cases.

An exhaustive search failed to uncover precise information on annual production for most short-lived firms. Coverage is worst for France and Germany, with precise information lacking for 81% of the firms in each country's industry; these account for 68% of the firm-years in France and 65% in Germany. Information on size is most complete for the British industry, for which precise information on size is lacking for 62% of the firms in the British industry—these firms contribute 43% of the firm-years of observation.

Hannan et al. (1998*a*) argue that information about a firm's size indicates clearly that its scale was very small. The counts often come from new vehicle registrations, which were presumably exhaustive, and from counts of surviving automobiles. Often the sources indicate that the firm produced only "a few" automobiles. In others, no mention is made of the scale of production. In both cases, a firm was coded as "small." Sometimes, the sources suggest that production levels were substantial, but they do not provide exact counts. For instance, this is the case when there are gaps in the yearly series at the end of a firm's history and previously reported production totals were large. In such cases, our research group distinguished "middle size" (the firm's production level in a year was much higher than "small" but considerably smaller than the scale of the largest firms in the industry at the time). In a few cases (mostly occurring during the interwar years), it appeared that a firm's production level approached those of the industry's biggest firms; size in such cases was coded as "large."

As in the previous research, absolute sizes are imputed to firms lacking precise information based on the size distributions of firms whose production levels are observed to impute sizes for the three categories. When a firm's yearly observation was coded as "small" and no more precise information was available, it was assigned a value from a uniform distribution ranging from zero to the first quartile of the size distribution for the historical period. Firm-years coded as medium and large were assigned the second and third quartile values, respectively.

Hannan et al. (1998*a*) analyzed the resulting data in two ways. In one, they merely distinguished the three size classes: small, medium, and large.[12] In the second approach, they used the natural logarithm of the value based on the precise measures and the imputed ones. There was little substantive difference in the results of the two kinds of analysis: both indicated that the rate of disbanding/exit is very high for the smallest firms and declines as a function of size. We follow the earlier research in using the constructed metric measure of size. We measured *relative size* of a firm as the ratio of each firm's size to the size of the largest firm in the national population at the time.

CONTROLS

We use a common population-level clock in the various analyses: industry age. The clock for each country begins at zero in 1885, the time of initiation of the French population of automobile manufacturing firms.[13] This choice

[12] For this analysis, they coded firm-years with precise information as small if the level was below the period's first quartile, medium if it fell in the interquartile range, and large if it exceeded the third quartile.

[13] This choice probably has little consequence for the empirical analyses, because the dates of initiation of these national automobile industries differs by a decade at most.

reflects the view that processes of legitimation likely spill over national boundaries (Hannan et al. 1995).

We control for changes in institutional conditions and industry structure with period effects, and we chose to follow the prior research on these populations in defining historical periods.[14] The analyses reported below also contain effects of economic depression, the level of the gross domestic product (GDP) adjusted for inflation (taken from Maddison [1991]), and the period effects. We excluded the years of the two world wars from the analysis because the production of motor vehicles for private use was stopped in all of these countries.[15]

STOCHASTIC MODELS AND ESTIMATION

The Hazard of Mortality

Each organization in the population has some chance of disbanding/exiting at any time during its tenure. The occurrence of such events is controlled by an instantaneous hazard. Because we lack information on the length of spells of prior existence for those firms that entered automobile production from other industries, the only feasible choice of organization-level clock, given our design, is *tenure*—the duration of the spell of automobile production. The half-life (considering all kinds of ending events) of an automobile producer has ranged from 1.8 years in the British and German populations to 2.6 years in the French.

Given a random variable, $Y(u)$ that records whether a firm has disbanded or exited at tenure u (in which case $Y(u) = 1$) or has not ($Y(u) = 0$), the disbanding/exit hazard can be defined as:

$$\mu(u) = \lim_{\delta \downarrow 0} \frac{\text{prob}[Y(u + \delta) = 1 | Y(u) = 0]}{\delta}, \qquad u \geq 0.$$

(If a firm exits the population by some other event [e.g., acquisition], we treat the spell as [noninformatively] censored at the observed event time.)

We represent the effects of changes in tenure with a piecewise-exponential specification. With the breakpoints denoted as $0 \leq \tau_1 \leq \tau_2 \leq \ldots \leq \tau_q$ and $\tau_{q+1} = \infty$, there are q periods: $I_p = \{u | \tau_p \leq u < \tau_{p+1}\}, p = 1, \ldots, q$. We estimate models with this general form with the method of maximum

[14] Specifically, the breakpoints for Britain are those used by Torres (1995): 1915, 1919, 1939, 1946, and 1968. The breakpoints for France and Germany are those used by Hannan et al. (1995): 1915, 1919, 1930, 1939, 1950, and 1970.

[15] Firms that did not resume production of automobiles after a war (often because their factories were destroyed) are treated as right-censored at the end of the last prewar year.

likelihood as implemented in TDA 6.2 (Röhwer and Pötter 1998). As in the prior research on these populations, we break the duration scale (in years) at: 0.5, 1.0, 3.0, and 7.0. With this choice, the first segment (0,0.5] includes dated events that occur within the first six months in the industry as well as cases that enter and exit at unknown times within the same year (as discussed above). The second segment (0.5,1] includes dated events that occur within the second six months and cases that enter at unknown time in one year and exit at unknown time in the next year. The third and fourth segments are defined similarly. The final segment begins at seven years and is open on the right.[16]

Our models specify that the disbanding/exit hazard is a function of tenure in the industry (u), industry age (t), a vector of variables ($\mathbf{s}_{iu}$) pertaining to size and prior experience (absolute and relative size and dummies for very small size and prior organizational existence [e]), a vector of other measured covariates ($\mathbf{x}_t$), including GNP, depression year, and density at founding, a function of contemporaneous density and density-squared, as well as the interactions of these density effects and industry age, denoted by $\varphi\,(\cdot)$. The key functions for assessing the arguments made above relate to niche width, market position, and niche-overlap density, denoted by $\psi\,(\cdot)$, and a function of changes in niche width and various measures of position, denoted by $\omega\,(\cdot)$. We estimate members of the general class of models of disbanding/exit with the form:

$$\mu_i(u,t) = \exp(m_p)\ \exp(\mathbf{s}'_{iu}\boldsymbol{\alpha}_p + \mathbf{x}'_{it}\boldsymbol{\pi})\ \cdot \varphi(n_t,t) \cdot \psi(nw_{iu}, n^{ov}_{iu}, pos_{iu}) \cdot \omega(\Delta W, \Delta P), \qquad u \in I_p. \tag{1}$$

Here m_p denotes a set of duration-specific effects; the log-linear link imposes the constraint that the baseline hazards be nonnegative.

This kind of specification allows the hazard of disbanding/exiting to be a *nonproportional* function of tenure, size, and prior experience as in Hannan et al. (1998*a*). These specifications allow tenure dependence to be negative for some size classes and positive for others. Adding effects of niche-related measures has hardly any impact on the effects of tenure and size. Therefore, the patterns summarized by Hannan et al. (1998*a*) continue to hold. Because this issue is not central to the present analysis, we simply report the relevant estimates without commenting further.

[16] The earlier research using these data showed that the main results are fairly insensitive to these choices, presumably because so few firms experience tenures of greater than seven years.

Changes in Position

For the other class of outcomes, change in niche width and market position, we have repeated yearly observations on firms (where the number of observations per firm is one less than the number of years of tenure in the industry because we use year-to-year changes). In other words, the data structure is an unbalanced panel. Although much recent organizational research analyzes such data with fixed-effect estimators (which uses only within-firm variation), we take advantage of a new class of robust estimators to analyze both between-firm and within-firm variation. Specifically, we use the method of generalized estimating equations (GEE), developed by Liang and Zeger (1986; see also Zeger and Liang 1986). This approach generalizes quasi-likelihood estimation to the panel context. Like quasi-likelihood, GEE requires specification of only the first and second moments of the distribution of the outcome, rather than the full distribution as is required for maximum likelihood.[17] Under mild regularity conditions, GEE estimators are consistent and asymptotically normal.

The outcome in each firm-year is a dummy variable that equals 1 if the firm changed the relevant dimension of its niche from the previous year and 0 otherwise. For the ith firm, we have u_i observations; the vector of outcomes can be written as: $\mathbf{y} = (\mathbf{y}_1, \mathbf{y}_2, \ldots, \mathbf{y}_N)'$. The covariates vary over firms and (in some cases) over time for given firms: $\mathbf{X} = (\mathbf{X}_1, \mathbf{X}_2, \ldots, \mathbf{X}_N)'$, where $\mathbf{X}_i$ is $(u_i \times k)$ and the number of covariates is $k - 1$. As in the usual framework for generalized linear models, one chooses a distribution for $\mathbf{y}$ and a link function to connect the outcome to the covariates. In this analysis, we obtain a (generalized) logit regression by choosing the binomial distribution and the logit link.

We expect that the disturbance process will exhibit autocorrelation of the usual panel type: observations for the same firm will tend to be correlated due to permanent and gradually changing unobserved firm properties. But, we assume that observations are uncorrelated for different firms. GEE requires a specification of a "working" correlation matrix for the within-organization correlation of observations. The implementation we used—the XTGEE routine in version 6.0 of STATA (StataCorp 1999)—allows a menu of choices for this matrix. We experimented with several, including the exchangeable correlation structure familiar from the standard random-effects specification for panel data, as well as first-order and second-order serial autocorrelation. We found that there is negligible autocorrelation for the French and German data. However,

[17] Barron (1992) discusses sociological applications of QL estimators (in the context of analysis of counts).

there is mild positive autocorrelation in the British data. For the latter, the estimates of key substantive effects were insensitive to specification of the working correlation matrix. Inspection of estimates suggested to us that the "exchangeable" version fits well. For consistency, we used this specification for all three data sets. That is, the working correlation matrix for each organization's observations has the following form:

$$R(\rho)_{s,t} = \begin{cases} 1 & \text{if } s = t \\ \rho & \text{otherwise} \end{cases} .$$

Finally, we based our testing on so-called robust standard errors, using the "sandwich" estimator developed by Huber (1967) and White (1982).

RESULTS

Rates of Disbanding/Exit

Estimates of our basic specifications appear in table 4. Hypothesis 1 receives strong support: niche width has a negative effect on disbanding/exit hazards in all three populations; the effect is statistically significant for Britain and France. Hypothesis 2 also receives strong support: overlap density has a significant positive effect on the hazard in all three countries.

According to these results, the worst case (from the perspective of life chances) is having a narrow niche that overlaps substantially with those of other organizations in the population. In other words, the highest hazards are for specialists in a market center. This pattern accords well with the central image of resource-partitioning theory.

Consider the situation from the perspective of a specialist on the periphery, one whose niche does not overlap with that of any other organization. Such an organization does not suffer the deleterious consequences of competition within its niche, nor does it reap any of the gains of a broad niche. Can organizations improve their life chances by broadening their niches? The answer to this question depends upon the distribution of organizations in the market, on the strength of the effects of niche width and niche-overlap density, and the possibility that change *per se* can elevate the hazard of disbanding/exit.

We can explore the first part of the answer by examining figures 1 and 2. Recall that movement away from pure specialism makes the number of overlaps increase sharply. So the specialists face a genuine dilemma.

We can get a sense of the "content" effect of change for a pure specialist by considering the multiplier of the hazard at different levels of specialism and overlap density. We continue to focus on the French population. In table 4, we see that this multiplier is $\exp(-0.06 \cdot W/1{,}000 + .005 \cdot NO)$.

TABLE 4
ML Estimates of Effects of Niche Width and Niche-Overlap Density on the Disbanding/Exit Hazards of European Automobile Manufacturers, 1885–1981

	France		Germany		Great Britain	
Tenure in the industry:						
$u < 0.5$	−5.40	(−3.81)	−6.77	(−5.15)	−3.81	(−3.63)
$0.5 \leq u < 1$	−5.35	(−3.77)	−6.41	(−4.90)	−3.42	(−3.26)
$1 \leq u < 3$	−6.04	(−4.26)	−7.05	(−5.38)	−4.15	(−3.98)
$3 \leq u < 7$	−7.81	(−5.91)	−14.93	(−6.19)	−5.51	(−5.47)
$u \geq 7$	−8.24	(−6.22)	−15.13	(−6.32)	−5.87	(−5.83)
ln(GDP)	1.16	(2.39)	.95	(1.28)	−.02	(−.04)
Depression year	.62	(3.02)	.80	(2.03)	−.12	(−.41)
Prior existence:						
$u < 3$	−.70	(−4.88)	−.83	(−4.74)	−.58	(−4.56)
$u \geq 3$	−.20	(−1.57)	−.59	(−2.45)	−.25	(−1.83)
ln(relative size):						
$u < 3$	−1.22	(−2.04)	−1.63	(−2.99)	−.98	(−2.12)
$u \geq 3$	−1.98	(−3.62)	−5.01	(−4.82)	−1.49	(−3.54)
ln(size)	−.04	(−.87)	.05	(.77)	−.04	(−1.38)
Size < 50	.62	(3.98)	.12	(.61)	.67	(4.24)
Density at entry	.01	(1.54)	.005	(.85)	.001	(.63)
European density (N_E):						
N_E	−.01	(−2.36)	−.01	(−1.09)	−.01	(−3.07)
$N_E \times$ ind. age ($\times 10^{-2}$)	.03	(1.01)	.08	(2.05)	.05	(2.28)
$N_E \times$ ind. age^2 ($\times 10^{-3}$)	−.003	(−.58)	−.01	(−1.90)	−.005	(−1.32)
Country density squared (n^2):						
$n^2 \times 10^{-3}$	.22	(1.85)	3.35	(2.82)	.12	(1.27)
$n^2 \times$ ind. age ($\times 10^{-3}$)	−.003	(−.42)	−.26	(−3.57)	−.01	(−1.07)
$n^2 \times$ ind. age^2 ($\times 10^{-6}$)	−.01	(−.07)	4.29	(3.83)	.10	(.85)
Niche width ($W \times 10^{-3}$)	−.06	(−1.92)	−.04	(−.74)	−.22	(−4.72)
Niche-overlap density (NO)	.005	(3.09)	.01	(3.68)	.01	(7.15)
N of spells	5,171		2,272		5,582	
N of events	718		309		810	
Log likelihood	−1,732.0		−642.4		−1,860.9	

Note.—Figures in parentheses are t-statistics; u denotes tenure in the industry in years. All specifications also contain historical period effects.

This multiplier is 1.0 for a pure specialist with no overlap.[18] For a pure specialist that is unlucky enough to find itself in the center of the market, NO might plausibly equal 100, giving it a multiplier of 1.65, meaning that its mortality hazard is 65% higher than that of the specialist in an isolated position on the periphery. The multipliers for center specialists in this scenario are 2.7 for Germany and Britain (the multipliers for peripheral

[18] Since we added one to all niche widths, the minimum value is actually 0.001, and the multiplier for such a case is 1.001.

specialists in all cases equals 1.0). Clearly specialists cannot persist in crowded market centers.

Less evident from the parameter estimates, the hazard for most generalists also exceeds the hazard for a peripheral specialist when the center is crowded. For instance, if a generalist experiences $NO = 100$, then its hazard of mortality exceeds the hazard for a peripheral specialist unless its niche is extremely wide, greater than 8,333 cc, which is very far out in the tail of the distribution (table 2). The level of niche width at which generalism is superior to specialism for the same circumstances are 25,000 cc for Germany (far outside the observed range) and 4,500 cc for Britain (well below the maximum but four times the mean). Suppose, in contrast, that concentration among generalists has taken place, that all specialists have been pushed out of the center, and that only three generalists remain in the center. Consider a remaining generalist with $W = 5{,}000$ cc. Since it overlaps with only two other firms, its multiplier is $\exp(-.06 \cdot 5 + .005 \cdot 2) = .75$, which means that its multiplier is 25% below that of an isolated specialist. These results too confirm the central intuition of resource-partitioning theory: it is reduced crowding in the center (concentration)—not simply generalism—that improves the life chances of generalists.

We addressed the functional form of the localized competitive effects of niche overlap by using a nonparametric approach, replacing the log-linear effect of overlap density in table 4 with three dummy variables indicating overlap of 1–5, 6–50, and greater than 50 (with 0 as the excluded category). Although the results vary among the three countries, in each case we find that overlap density does not raise the hazards until it reaches a count higher than 50.

We test hypothesis 3 by adding an interaction of niche-overlap density and industry age to the models whose estimates were reported in table 4. As predicted, the estimated interaction effect is negative (and significant) in all three populations in table 5. For example, in France, the effect of niche-overlap density, strong at the inception of the industry, has been eliminated entirely 50 years later in the industry evolution. Competitive crowding and its positive effect on the hazards tend to be more pronounced in the early stages of the industry evolution.

Now we turn to the process effects of organizational change on mortality, net of the effects of the niche width and niche-overlap density that result from the change. Table 5 reports estimates of specifications of the effects of niche expansion and niche contraction by 10% or more, along with a "change clock," which is reset to zero whenever a firm makes either type of change. We explored the issue of nonproportionality of these effects, and we determined that the niche-width effects vary with industry tenure in France but not in Germany and Britain. Overall, we find that

TABLE 5
ML ESTIMATES OF THE EFFECTS OF NICHE WIDTH, OVERLAP DENSITY, AND POSITION CHANGE ON THE DISBANDING/EXIT HAZARDS OF EUROPEAN AUTOMOBILE MANUFACTURERS, 1885–1981

	France		Germany		Great Britain	
Niche width ($W \times 10^{-3}$)	−.06	(−2.01)	−.08	(−1.35)	−.21	(−4.54)
Niche-overlap density (*NO*)	.01	(2.91)	.06	(3.21)	.01	(4.38)
Niche-overlap density × industry age ($\times 10^{-2}$)	−.02	(−2.02)	−.12	(−2.53)	−.02	(−1.95)
Change in niche width expansion:						
$u < 3$	.33	(1.67)	.53	(2.86)	.03	(1.33)
$u \geq 3$	.22	(1.20)	.53		.03*	
Contraction:						
$u < 3$	.50	(2.33)	−.03	(−.11)	.09	(.61)
$u \geq 3$	−.27	(1.20)	−.03*		.09*	
Change clock (niche width)	.03	(1.61)	.03	(.75)	.03	(1.33)
Log likelihood	−1,724.6		−635.5		−1,857.8	
LR test vs. model in table 4 (*df*)	14.8 (6)		13.8 (4)		6.2 (4)	

NOTE.—Figures in parentheses are *t*-statistics; *u* denotes tenure in the industry. All specifications also contain all covariates in table 4.
* Indicates that a coefficient is constrained to equal the one immediately above.

the process effects of change are positive, that is, change increases the hazard of disbanding/exit, whenever the effect is statistically significant. Moreover, expansion appears to be more hazardous than contraction. Expansion elevates the hazard in all three countries, although the effect is not significant in Britain. In addition, the effect is nonproportionate in France: the effect is smaller after an organization's tenure in the industry exceeds three years. The effect of niche contraction is positive and significant only for French firms with an industry tenure of less than three years (such change increases their hazards by 65% according to this result). The contraction effects are not significant in the German and British populations.

The coefficient of the change clock tells how the hazard changes with the time elapsed since the organization's most recent change. Generally research that uses specifications like ours finds that the deleterious effects of change erode over time. This pattern is usually termed negative duration dependence. This is not the case in the populations we study. In contrast, we find positive (but not significant) duration dependence in each case.

Table 6 reports estimates of an alternative representation of the effects of change, looking at change in market position. These specifications, which include effects of measures of market position and change in market

TABLE 6

ML Estimates of an Alternative Specification of the Effects of Niche Width, Overlap Density, and Position Change on the Disbanding/Exit Hazards of European Automobile Manufacturers, 1885–1981

	France		Germany		Great Britain	
Niche width ($W \times 10^{-3}$)	.004	(.10)	.01	(.14)	−.17	(−3.14)
Niche-overlap density (*NO*)	.01	(2.50)	.06	(2.91)	.01	(3.67)
Niche-overlap density × industry age ($\times 10^{-2}$)	−.03	(−2.23)	−.12	(−2.38)	−.03	(−2.53)
Change in niche width:						
Expansion	−.07	(−.38)	.29	(1.23)	−.32	(−2.23)
Contraction	−.17	(−.81)	−.30	(−.88)	−.30	(−1.84)
Change clock (niche width)	.06	(.97)	−.02	(−.28)	−.002	(−.05)
Position:						
Distance above market center ($\times 10^{-2}$)	−.04	(−2.58)	−.02	(−.96)	−.01	(−1.76)
Distance below market center ($\times 10^{-2}$)	−.004	(−.77)	−.01	(−1.27)	.001	(.20)
Change in relative position ($\Delta P \times 10^{-2}$)	−.01	(−1.19)	−.04	(−2.10)	.001	(.22)
Any change in absolute position ($\Delta P^a = 1$)						
$u < 3$	.65	(4.31)	.43	(2.21)	.95	(7.66)
$u \geq 3$	.32	(1.73)	.43*		.34	(2.11)
Change clock (absolute change)	−.03	(−.53)	.06	(.68)	.04	(.65)
Log likelihood	−1,711.1		−627.9		−1,824.9	
LR test vs. model in table 4 (*df*)	41.8 (10)		29.0 (9)		72.0 (10)	

Note.—Figures in parentheses are *t*-statistics; *u* denotes tenure in the industry. All specifications also contain all covariates in table 4.

* Indicates that a coefficient is constrained to equal the one immediately above.

position, also separate the effects of process and content change.[19] It appears that in the European automobile industries, being a "high end" producer has been a beneficial position. The coefficient capturing distance of a firm's niche center above the market center has a negative effect on the hazard; the effect is significant for the French and British populations. In France, for example, a company whose production centers around a model that is more powerful than the most sought after generalist model by 1,000 cc reduces its hazard of disbanding/exit by about a third.

The effect of relative position change—change that does not necessarily involve organization-level transformation—is significant only in Germany, where the estimated effect implies that the hazard drops by about 30% if a firm repositions its niche center by 1,000 cc (i.e., whenever a firm's

[19] To further investigate the effect of change in relative position, we allowed the effect to differ by direction (i.e., toward vs. away from the market center), but this distinction was not justified by the results.

"average" car becomes more similar or dissimilar to the "average" generalist car by an engine capacity difference of 1,000 cc). So, it appears that, while in France and Britain being a high-end specialist confers an advantage, the real benefit in Germany came from constant exploration, even if it was incidental.

Paradoxically, as the next set of results indicate, exploration generally comes at a very high cost and proves beneficial for life chances only as long as it is incidental. The estimates for the effect of absolute change (change that, regardless of its direction, involves repositioning by the focal firm) are positive and highly significant in all three countries. In France and Britain, these effects are also nonproportionate; they are much stronger for firms with less than three years of tenure in the auto industry. In Britain, such firms are 2.6 times more likely to fail, and they are 1.9 times more likely to fail in France. Once their industry tenure surpasses three years, those disadvantages decline to a level at which they increase the hazard by about 40% in both countries. In Germany, the absolute change effects increase the hazard by roughly one half, irrespective of tenure. In France and Britain, where the absolute change effects hinge on tenure, the initial hump in mortality disappears to reveal monotonic negative tenure dependence. Overall, the results in tables 5 and 6 provide strong support for hypotheses 4 and 5.

Summarizing the main results presented so far, we note two sets of effects that stand out as robust and consistent across the three populations of automakers. Both competitive crowding and organizational change (its process dimension, in particular) significantly elevate mortality hazards. Earlier we also argued that a possible second-order (indirect) effect of competitive crowding might heighten mortality hazards by increasing the propensity of firms to initiate change. To test this proposition, we now consider estimates of models of the rates of change in niche-width and (absolute) market-position.

Change in the Niche

We report results for change in the center of the niche in table 7, which reports GEE results for the panel data on change. Overlap density has a positive effect on the propensity to change. The effects are highly significant for France and Britain but not Germany. The effects in the French and British populations are strong in substantive terms as well. For instance, a French firm's log-odds of absolute position change is 112% higher when it overlaps with 75 firms as contrasted to the situation in which it has no overlaps. In Germany, the log-odds of change at $NO = 75$ is 35% higher than with no overlaps. So, in accord with hypothesis 6, we find evidence that competitive intensity not only increases mortality

TABLE 7
GEE Estimates of Pooled Logit Regression Models of (Any) Change in Absolute Position by European Automobile Manufacturers, 1885–1981

	France		Germany		Great Britain	
Constant	−2.97	(−1.36)	−1.07	(−1.64)	.24	(.51)
Tenure in the industry	−.01	(−.86)	.01	(.45)	.09	(6.41)
Depression year	.71	(.57)	.28	(.85)	−.25	(−1.13)
ln (GDP)	−.62	(−1.41)	−.25	(−.46)	.46	(1.40)
Prior existence	−.24	(−1.21)	−.37	(−2.28)	.04	(.35)
ln (relative size)	−.31	(−.51)	−.09	(−.52)	.49	(2.68)
ln (size)	.05	(.50)	−.07	(−.81)	.0002	(.006)
Size < 50	.28	(1.27)	−.04	(−.16)	−.29	(−2.15)
% niche width ($W \times 10^{-3}$)	.02	(.23)	.11	(1.56)	−.08	(−1.50)
% niche-overlap density (*NO*)	.01	(4.12)	.01	(1.21)	.004	(3.09)
N of prior changes in niche width	−.75	(−3.81)	−.93	(−2.50)	−.39	(−5.94)
Distance above market center ($\times 10^{-2}$)	.12	(1.14)	−.05	(−2.51)	−.02	(−3.20)
Distance below market center ($\times 10^{-2}$)	.01	(1.13)	.01	(2.05)	−.002	(−.94)
N of prior changes in absolute position (NPC)	1.74	(6.01)	1.37	(3.26)	.29	(6.70)
NPC × tenure	−.04	(−3.71)	−.01	(−4.32)	−.003	(−4.76)
NPC × niche width	−.06	(−1.13)	−.05	(−2.19)	.02	(2.19)
N of observations	5,171		2,272		5,582	
N of firms	819		373		987	
Wald χ^2	309.90		105.45		223.09	

Note.—Figures in parentheses are *t*-statistics; all specifications also contain historical period effects. Scale parameter = 1; *df* = 18.

directly, but it also does so indirectly by increasing the rate of organizational change in two of three populations studied.

Our hypotheses concerning learning and inertia hold that greater cumulative absolute-position change will trigger subsequent changes in absolute position but will deter change in niche width. Support for the first part of this proposition is strong; the estimates in table 7 show that experience with the same change has a strong positive effect on the propensity to change further. Additionally, consistent with earlier studies examining rates of organizational change (Amburgey et al. 1993; Minkoff 1999), we find that the momentum of change declines with industry tenure.

We also find support for the proposition that experience with one type of change deters the occurrence of another type of change. Cumulative niche-width change has a significant negative effect on the rate of position change in all three countries.

Our final hypothesis predicts that the effect of previous changes on the likelihood of repeating the same type of change declines with niche width (regarded as a measure of complexity). The estimated effects of the product of niche width and number of prior changes in position on the propensity to change position are negative, as predicted, for only two of the three populations, and the effect is only significant for the German population.

Effects of Other Covariates

To this point, we have focused on the effects that bear directly on our arguments. However, we embedded these effects in a model that specifies effects of size, industry tenure, density, and several environmental covariates. Several of these effects deserve note. First, adding the effects of niche width and niche-overlap density do not change the pattern found earlier without these effects (Hannan et al. 1998*a*). The hazards of disbanding/exit decline with relative size and increase with industry tenure, and the effect of each depends upon the level of the other (the effects are nonproportional). In particular, there is positive age dependence for small firms and negative age dependence for large ones.

One set of findings, concerning the dynamic multilevel specification of density dependence, is new. The theory of multilevel density dependence holds that different levels of population density drive legitimation and competition. Modified to account for the nonsymmetric effect of population density at different stages of the industry evolution (Hannan 1997), the model, in the form specified here, posits that the baseline density effects (low counts increasing survival through legitimation and high counts increasing mortality through competition) reverse direction as an industry structure evolves and solidifies. But resurgence in density in the late cycle of industry evolution again reverses the direction of effects to the original pattern. This account is consistent with the resource-partitioning story explaining the late surge in population density with the proliferation of specialists on the market periphery.

This model has previously been estimated for founding rates but has not, to our knowledge, been applied to mortality rates. The results in table 4 offer strong support for the predictions of the theory. Looking at the main effects of density, we see that Europe-wide density has a negative effect on mortality rates and (the square of) country density has a positive effect. These results agree with the view that legitimation processes flow more easily over national borders than do competitive processes. Looking at the interactions of these effects with industry age, we see that, with the exception of the interaction between the squared terms of industry age and country density in France, the legitimation and competition effects have the predicted directions for all three countries.

DISCUSSION

The findings of this research expand our knowledge of the processes investigated by three well-developed and empirically tested theory fragments: density dependence, resource partitioning, and structural inertia. Our results help to establish conceptual links that integrate these theory fragments into a coherent research stream similar to the Mertonian type of theory of the middle range, thus further consolidating the broad knowledge base accumulated within the ecological framework of organizational analysis.

Our contribution to density dependence here lies in elaborating the multilevel form of the model. Similar to models of locally partitioned density-dependence, we describe a process that could be termed "niche-localized" density dependence.

At the core of our argument lies the assumption that a process of constitutive diffusion of a new product resembles the legitimation of a new organizational form. A single organization can rarely carry out the institutionalization of a new line of products or services. That many companies are willing to invest in and pursue an emerging market domain provides a sign that inspires trust and confidence in potential customers and partners alike. The presence of more than one actor in a market segment also reflects positively on the status of early entrants.

Clearly, the transition from monopoly to duopoly poses constraints on access to resources and introduces a competitive relationship. But, at low levels of niche-overlap density, the disadvantages posed by the entry of competitors is minimized; indeed our results suggest that they are neutralized, by the subsequent entrants' contribution to affirming the identity of the new product. Growth in local density also aids in defining, expanding, and fortifying the boundaries around the evolving market niche. This line of reasoning agrees with the implication of the resource-partitioning model that the flattening of the resource distribution over time results from the entry of specialists whose arrival promotes the consolidation of new market niches and changes consumer tastes.

We find that there is a threshold level in niche-overlap density, above which niche crowding heightens mortality. Virtually all ecological studies that have analyzed the distribution of population density over time report a similar pattern: density increases, slowly at first, and then at a higher rate until it reaches a peak followed by a decline. This decline in the number of organizations can be explained (at least partly) by the higher exit rate of existing firms that fail in the competitive process once the limits of the population's carrying capacity are reached.

We find that this effect might also be indirect. Our findings suggest that competitive crowding propels organizations to change their niche widths and positions. When this happens, organizations can change their strategies to those that seek to find a viable position outside of the market center, a process that leads to resource partitioning. But, change in range of product offerings and in location proves to have vital consequences. Organizations that attempt such change suffer increased exposure to environmental selection. So, it appears that density dependence breeds resource partitioning; that is, competitive crowding also has an indirect effect on mortality by decreasing the survival chances of organizations exploring less competitive market segments, a process that gives rise to the formation of peripheral niches with thinner but untapped resources.

The resource-partitioning model predicts that market segmentation and rising concentration improve the survival chances of specialists, but this model does not specify how specialists come to proliferate outside the market center. Our findings, however, imply that the survival advantages associated with location on the periphery might hold only for new market entrants, because the deleterious effects of changes in niche width and position might offset those advantages. This is especially true in light of our finding that the hazard of failure due to niche width and position change does not diminish with time. So it seems that the specialist advantage comes at the cost of becoming a specialist—a finding that underscores the importance of separating the effects of content and process change when studying organizational transformation.

Organizational change is precarious partly because of the difficulty of foreseeing the amount of related subsequent structural transformations that will be induced by an initial change (Barnett and Carroll 1995). Until all such changes are completed, the organization is unfit to operate at its previous levels of accountability and reliability. In other words, a "recovery" period follows nontrivial transformation attempts. During this period, the process consequences of organizational change are hard felt. In this research, we found no evidence that an actual recovery from the negative impact of process change is certain to occur. On the contrary, it appears that once structural inertia triggers liability to selection, this effect is continuously perpetuated and amplified with time.

We believe that our approach to defining organizational strategy along the generalist—specialist dimension by using technological niches of organizations can be explored and refined in future research on resource partitioning. Variance in organizational niches can be used to complement measures of size and product characteristics (e.g., content coverage in newspapers), frequently used to capture this distinction in previous analyses. The effects of industry concentration, for example, can be tested on the subset of narrow-niche organizations, or those located outside the market center. Similarly, the proposed scale-based selection mechanism that accounts for consolidation among generalist organizations (Carroll and Swaminathan 2000; Dobrev and Carroll 2000) can be applied to organizations with wide niches. Overall, the use of the niche construct can be useful in explicating the intricacies in the relationship between organizational size, strategy, and resource partitioning (Dobrev, Kim, and Carroll 2001).

The research presented here points to the variety of ways in which the niche construct could be exploited in other research fields. Our findings about the negative relationship between niche change and organizational survival, for example, can be extended to the sociological investigation of collective action in an interesting way. For instance, Olzak and Uhrig (1999) suggest that it is helpful to think about the niche of a social movement in terms of its tactical repertoire and routines for organizing, which eventually become embedded in the movement's identity. Relying on the content/process distinction, one can test if the "fade-away" of social movements occurs when a movement attempts to broaden or diversify its tactical array. Even though new tactics might become more appealing to members, more socially acceptable, and thus more effective than old ones, the transition to different routines and tactics itself might imply that the movement's identity has been lost, that it has been debauched, coopted, or defeated. More broadly, much sociological analysis rests on assumptions about embeddedness and structure. Defining and measuring the niche along dimensions and attributes of individual and collective social actors could yield the conceptual utility and the research versatility needed to investigate the dynamic relationship of persons and organizations to their positions in the social structure.

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